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Virtually Pain Free!
- Virtual Reality for Procedural Sedation and Analgesia

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Abstract
The patient's psychological state of mind can influence the dosage of sedatives needed to achieve the target sedation level. Since the greatest threat to the safety of a sedated patient is airway compromise and/or respiratory arrest, non-pharmacologic techniques have become popular in the pre-procedural and pre-operative areas to relieve parental and patient anxiety. They serve as useful adjuncts to promote anxiolysis, analgesia and sedation, and to reduce adverse events by reducing reliance on medications.
Traditional distraction techniques are moderately effective in pain reduction during procedures. A recent and significantly more powerful distraction with little or no side effects is immersive virtual reality (VR). VR distraction programs, both outside and inside the operating room can effectively improve patient satisfaction with anxiety-reduction, sedation-sparing and hemodynamic benefits in a variey of clinical applications.
Virtual reality (VR) is referred to as "distraction on steroids" is an advanced form of human-computer interface, where operators enter and interact with a highly naturalistic computer-generated environment. The convergence of multisensory input (sight, sound, touch) gives VR participants a strong illusion of 'going into' the computer-generated environment, a sensation known as 'presence' in the virtual environment. VR can, thereby, serve as a replacement to procedural sedation for both pediatric and adult population and offer important benefits. (1)
Over the last 15 years, the use of virtual reality (VR) has been utilized for various educational (computer assisted learning), training (simulation), and research purposes with nurses, physicians, and other healthcare providers. However, more recently, the technology has been modified for child and adult use in clinical settings. Many investigators have begun to use the technology to entertain, educate, and divert attention away from the associated symptoms of painful medical interventions.

Keywords: Virtual reality, analgesia, procedural sedation, distraction

Introduction
Procedural sedation (PS) is a 'technique of administering sedatives or dissociative agents with or without analgesics to induce a state that allows the patient to tolerate unpleasant procedures while maintaining cardiorespiratory function. It results in a depressed level of consciousness that allows the patient to maintain oxygenation and airway control independently. (The American College of Emergency Physicians (ACEP)
Procedural sedation (PS) also known as conscious sedation refers to techniques, medications, and maneuvers that is tailored to enable a patient tolerate unpleasant or painful procedures and avoid potential traumatic memories associated with such procedures. Proper use of PS targets a successful procedure while decreasing the time required to perform it, with additional safety for the patient and personnel while attending the patient outside of the operating theater, such as emergency, dentistry, radiology, and gastrointestinal endoscopy.
Sedation, analgesia and dissociation are separate concepts.

a) Sedation is enabling the patient to remain immobile;
b) Analgesia is pain relief by central or peripheral interventions
c) Dissociation is the production of a state of mind-body separation.

Apart from the Ramsay and modified Ramsay scoring system and the Observer's Assessment of Alertness Scale, the most practical and commonly accepted terms for sedation depth are:

a) Minimal: also called anxiolysis*;* the patient remains awake but relaxed, able to interact.
b) Moderate: also called conscious sedation, the patient has depressed consciousness but will respond to verbal requests or react to touch. Breathing remains intact, and no support is needed.
c) Deep: The patient cannot be easily aroused but will respond to repeated or painful stimuli. Breathing may be impaired and may need to be supported.
d) Dissociative: a trance-like state wherein the patient remains awake but unaware of the pain and retains no memory of the event. They can follow commands, and airway reflexes remain intact. (2,3)

Virtual Reality (VR)

VR is the interaction between a participant and a simulated three-dimensional, immersive world. VR can distract patients and draw attention away from their anxiety, pain, and discomfort and form part of a multimodal approach to the management of procedural pain This technique has been referred to as a ."distraction on steroids". The distraction provided by VR takes the patient's focus away from painful experiences and increases their pain threshold and tolerance, making medical interventions significantly more tolerable. It continues to benefit patients even when it is used repeatedly and superior to placebo and controls.VR systems can be specifically designed to distract patients from the painful or anxiety generating stimulus.

Components of VR System

A virtual reality system consists of software and hardware. The software programs create the objects and environment of the virtual world and control the interactions which take place between them. The hardware are printed circuit boards that perform the calculations and graphics cards to produce the images of the virtual world. A head mounted display system or VR goggles presents a realistic and focused image to the user 5-8 cm from the eye and sound inputs from specialized headphones. (Fig 1) The user is thus effectively isolated from the real world and the degree of immersion in the virtual environment is therefore enhanced. (4)

Fig 1: VR analgesia during phlebotomy.

In immersive VR, the participant is engaged in a simulated world with visual and auditory interactive feedback. This is more effective than non-immersive (visual illusions only).

The VR experiences have been customized to minimize physical body movements by allowing patients use eye-movements and/or mouse tracking to aim snowballs at virtual snowmen and other target practice scenarios. This keeps the patient physically still during the medical procedure or wound care.

During VR physical therapy (where motion is desired), with hand, head, and body movements, patients are enabled to perform actions in sync with virtual images like robots, pirates, witches and other characters.

Physiological Effects of VR

VR results in a decrease in diastolic blood pressure, heart and respiratory rate, temperature, muscular tension, temperature, skin conductance, and serum carbon dioxide levels, similar to that seen with decreased anxiety levels. (5)

Evidence Base For VR

fMRI studies demonstrate that VR significantly reduces pain-related brain activity in the anterior cingulate cortex, primary and secondary somatosensory cortex, thalamus, and insula and provide analgesia comparable to that of hydromorphone. (,6,7,8,9)

Clinical Applications of VR

(a) Phlebotomy

In the outpatient phlebotomy clinics, VR reduced caregiver and patient distress, increased clinician satisfaction, and improved efficiency. Children undergoing blood sampling and intravenous cannula insertions in the emergency department reported significantly greater reductions in fear of pain using immersive VR when compared to watching television cartoon shows or receiving standard distraction. However, there was no significant reduction in pain intensity, but significantly less fear and greater satisfaction was experienced with VR compared to active control. (10,11)

(b) Chemotherapy

Peripherally Inserted Central Catheter (PICC) line insertion did not require patient restraint and VR was associated with reductions in anxiety and greater caregiver satisfaction. (12,13)

(c) Wound Dressings

VR has been shown to alleviate preoperative anxiety, facilitate the induction of anesthesia, alleviate pain and anxiety in children during burn dressings. For daily burn wound care procedures, opioid analgesics alone are often inadequate. Since most burn patients experience severe to excruciating pain during wound care. 84% of patients given morphine still rated wound care pain as intolerable.VR anesthesia has the potential to minimize pharmacological therapy, thereby reducing risks associated with sedation. (14,15)

(d) Dental Procedures

VR distraction reduced the self-reported levels and physiological indicators of anxiety, fear, and pain during dental procedures. In the pediatric population, VR decreased reported pain and anxiety levels with accompanying decreases in the pulse rate during and after restorative dental treatment, buccal infiltration anesthesia,

periodontal scaling and root canal procedures, as well as inferior alveolar nerve block (IANB) for mandibular tooth extraction when watching a movie. (16,17,18,19)

(e) Preoperative VR

preoperative VR tour of the operating theatre was effective in alleviating preoperative anxiety and increasing compliance during induction of anaesthesia in children undergoing elective surgery.

The use of VR could lessen the perioperative anxiety of children by maintaining a virtual child-parent connection while avoiding the potential drawbacks to having parents actually in the operating room before and during induction of anesthesia.

Despite adequate regional or neuraxial anesthesia, patients may receive doses of intraoperative sedatives which can result in oversedation and potentially avoidable complications. VR could prove to be a valuable tool for patients and providers by distracting the mind from processing noxious stimuli resulting in minimized sedative use and reduced risk of oversedation without negatively impacting patient satisfaction. (20,21,22,23)

(f) Endoscopies

VR has been used as an adjunct to upper esophagogastroendoscopies , colonoscopies and transnasal and urological endoscopies. VR has eliminated the need for sedation or anesthesia and reduced the associated costs. (24,25,26)

(g) Physical Therapy

Physical therapy strives to create a safe and replicable environment, where patients can improve upon limitations in specific activities of daily living (ADL) that resemble their day-to-day functioning. VR through telerehabilitation offers remote therapy for patients who do not have the luxury to travel to urban-located clinics. Virtual characters, also known as avatars, can provide the user with a greater sense of reality and facilitate meaningful interaction

VR is used as a diagnostic tool to assess postural stability in patients with Alzheimer's disease and those with balance impairments secondary to a mild traumatic brain injury (mTBI). VR has also been used to assess gait differences, increased stepping latencies

and functional deficits like gait performance, balance deficits, postural sway, upper extremity functional reach and grasp, endurance, or phantom limb pain. Remobilization of range of motion for joints limited by disease or burns has been effectively managed with VR. (27,28,29)

(h) Obgy & Labour Analgesia

Virtual reality is an effective complementary non-pharmacological method to reduce pain during episiotomy repair. VR is a potentially effective technique for improving pain and anxiety during labor. A high level of patient satisfaction with the use of immersive VR during labor. A majority of parturients in the VR group opted to use VR again in future labor. VR improved pain scores in early labor and contributed positively to the overall childbirth experience (30,31,32,33)

(i) Chronic Pain Management

Pain requires conscious attention and VR draws heavily upon this so that there is less of this cognitive resource to nociceptive inputs. There are inconsistent findings for the use of VR to reduce chronic pain. Although VR effectively reduces chronic pain intensity during and immediately after the VR exposure, lasting analgesic effects have not been observed in various studies. (34,35)

Limitations of VR

Very high expense, difficulty in use, and bulkiness issues have recently been eliminated as VR technology is currently improving at a fast pace, thus increasing its potential for medical dissemination. Easy to use, highly distracting, wireless, and battery-powered VR products like Oculus VR, CAREN, Samsung Gear VR, Psious, Nintendo Wii and Virtualis are currently available to the anesthesiology community at an affordable price range.

Conclusion

Implementation of a virtual reality distraction protocol in the operating room or otherwise for procedural sedation can effectively improve patient satisfaction, reduce perioperative anxiety with improved hemodynamic stabilization. The technique is free from any complication related to the device and has superior acceptability from the patient's, their careers and the medicosurgical team.

The high potential and diversity of applications of VR and AR in medicine are already highly visible. Further improvements in these technologies will enhance their functionality and affordability, making them more accessible to patients. This will finally translate to significant therapeutic impact in the area of procedural sedation.

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