(Acta Anaesth. Belg., 2020, 71, 145-150)

Regional anesthesia combined with virtual reality hypnosis for extended orthopedic surgery: two case reports

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Abstract : *Background :* Virtual reality hypnosis is a combination of visual immersion in a virtual reality environment and clinical hypnosis. It can be used in addition to conventional techniques, for sedation and pain management during wound care. Patients undergoing painful and long-lasting procedures under regional anesthesia could also benefit, from this technique alleviating the need for sedative-hypnotic medication.
Case presentation : Two patients with relative contra-indications for general anesthesia underwent lengthy orthopedic surgery of the upper limbs under regional anesthesia with additional virtual reality hypnosis. Written informed consent was obtained from both patients before surgery. A 69-year-old man, with a previous medical history of severe symptomatic aortic valve stenosis (ɵ 0.69cm^2, max/mean gradient of 91/58mmHg) sustained a proximal humerus fracture-dislocation and was scheduled to undergo shoulder hemi-arthroplasty. Anesthesia was provided with ultrasound-guided continuous interscalene block at the C5-C6 level (11mL levobupivacaine 0.5%) combined with a single-shot superficial cervical plexus block (6mL levobupivacaine 0.5%). The second case was a 56-year-old man suffering from rheumatoid arthritis with severe restrictive lung function due to interstitial lung disease and bilateral bronchiectasis. He received a unilateral elbow prosthesis. Continuous infra-clavicular brachial plexus block, performed under ultrasound guidance was provided (20 mL mepivacaine 1.5%). Both patients required prolonged immobilization on the operating table. We used virtual reality hypnosis to induce sedation and improve comfort without using medication. This was provided by headphones and head-mounted goggles, showing computer generated images of underwater scenes (Aqua module, Oncomfort ™). Both surgeries were uneventful during which time cardiorespiratory stability was maintained. Patients were comfortable during and satisfied after surgery. No sedative drugs were given before nor during the procedures.
Conclusion : Non-pharmacological sedation can be achieved with virtual reality hypnosis. When combined with regional anesthesia, this technique provides satisfactory sedation when pharmacological methods may be hazardous.

Key words : Virtual Reality ; hypnosis ; regional anesthesia ; pain management.

Background

The application of virtual reality (VR) for clinical purposes is not novel (1). In the past this technology was successfully applied during the care of patients with burn injuries, decreasing the need for opioids and increasing patient comfort (2). At that time the appliances required to provide VR were a lot bulkier than they are nowadays. The entertainment industry has provided us with smaller devices, making them more applicable in a clinical setting. This technique offers a feeling of immersion, the extent to which technology delivers an inclusive, extensive, surrounding and vivid illusion to the senses of anyone (3). It also provides a sense of presence which is a state of consciousness where one has the sensation of being in this VR environment. Over two decades ago, a review discussing the use of VR in anesthesia highlighted the deficiencies of the available technology for medical applications (4). VR can be used as a medium to deliver distraction, with good results for managing pain and distress during painful procedures (5-8). Patients respond favorably to this kind of distraction provided through VR, such as a controlled thermal heat stimulus given to the skin, transurethral microwave thermotherapy or burn wound care (9-11). The use of virtual reality distraction (VRD) has even been

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Paper submitted on October 30, 2019 and accepted on May 19, 2020
Conflict of interest: None

successfully demonstrated in an operating theatre during orthopedic surgery (12). The goal of exposing patients to a VR environment in a clinical setting is to manage their pain and distress. Similarly, hypnosis has been used effectively for both acute or procedural related pain, or chronic pain management, with patients experiencing a significant positive effect on pain perception and distress (13, 14). The surgical settings in which hypnosis was applied, are mostly restricted to minimal invasive surgeries such as percutaneous vascular and renal surgery, biopsies or burn wound care. Virtual reality hypnosis (VRH) is when the immersive imagery from a VR device and clinical hypnosis are combined. With this technique the induction of hypnotic analgesia is being guided by VR. The authors of this case report hypothesize that a combination could improve the results of both techniques individually. Furthermore, combined VRH has shown advantages in comparison to drug-induced sedation regarding the respiratory side effects and anesthesiologist's satisfaction (15). Limiting opioid use might reduce opioid-related adverse side effects or the potential for misuse (16). In this article, we describe two cases of prolonged orthopedic surgery in patients who had a relative contraindication for general anesthesia. Both case reports illustrate how pharmacological sedation was avoided by using VRH in combination with regional anesthesia (RA).

Case Presentations

Case 1

A 69-year-old man (BMI 26.8 kg/m^2) required a hemi-arthroplasty procedure of the left shoulder following trauma sustained during a syncopal episode. The patient had previously undergone aortic valve replacement 8 years earlier, but due to severe symptomatic restenosis of the bioprosthesis, a secondary trans-catheter aortic valve repair had been planned for the near future (ɵ 0.69cm^2, max/mean gradient of 91/58mmHg). Further medical problems included arterial hypertension and mild (GOLD grade 1) Chronic Obstructive Pulmonary Disease (COPD). His general practitioner reported mild alcoholism. On clinical inspection we observed a relative inactive patient with a metabolic equivalent score (METS) lower than three (17). His activity was limited to slow-paced walking and he didn't perform any activities of a moderate or profound intensity. A complete blood count showed a hemoglobin level of 7.8 g/dL. To improve the patient's condition, two units of packed cells were administered before surgery, which was planned nine days after the trauma. Due to his cardiac status, RA was considered the best option for the surgery. A continuous interscalene block at the C5-C6 level was performed under ultrasound guidance (P9, General Electric, USA), in combination with nerve stimulation at 0.4mA (Stimuplex, BBraun, Melsungen, Germany) and the use of an injection pressure limiter (NerveGuard, Pajunk, Geisingen, Germany). An interscalene catheter (Contiplex, BBraun, Melsungen, Germany) was placed following injection of levobupivacaine 0.5%, 11mL (Chirocaine, Abbvie, Wavre, Belgium). Additionally, a single-shot superficial cervical plexus block was performed with 6mL of levobupivacaine 0.5%. Hemodynamic monitoring was applied with pulse oximetry (SpO_2), electrocardiography (ECG) and invasive blood pressure measurement via a right radial arterial catheter. The surgical procedure lasted 90 minutes during which the patient remained hemodynamically stable. No sedative medications were used pre- or perioperatively. The postoperative period was uneventful, without the need for intensive care, and the patient was discharged four days after surgery.

Case 2

A 56-year-old man (BMI 22.8kg/m^2) with severe rheumatoid arthritis was scheduled for an elective prosthetic replacement of his painful and disabled left elbow joint. Clinical cardiac function was satisfactory (METS > 3). Preoperative assessment revealed severe restrictive lung function secondary to interstitial lung disease and bilateral bronchiectasis, most likely related to chronic use of corticosteroids. Pulmonary function testing demonstrated a FEV1/FVC ratio of 76% (Forced Expiratory Volume in 1 s / Forced Vital Capacity) a Forced Vital Capacity of 1.78L (47% of predicted value) and a Forced Expiratory Volume in 1 s of 1.36L (47% of predicted value). He reported a dyspneic feeling in rest and a marked limitation while performing physical demanding activities such as cycling or climbing the stairs. A preoperative ECG was normal. RA was considered the best anesthetic technique due to the limited pulmonary function. A continuous infraclavicular block was induced with ultrasound guidance (Sonolong, Pajunk, Geisingen, Germany) along with nerve stimulation at 0.4mA and the use of an injection pressure limiter. Twenty mL of mepivacaine 1.5% (Scandicaine, Aspen Pharma, Dublin, Ireland) was injected. Setup was comparable to the first case regarding routine monitoring. No

sedative medications were administered before or during the surgery. Monitored parameters remained stable during the entire surgery, which lasted for approximately 2 hours. The patient was discharged on the 4th day of hospitalization.

Virtual reality hypnosis

In both cases VRH with a head mounted display (HMD) and headphones was proposed as additional non-pharmacological sedation. A written informed consent from both patients was obtained during a preoperative assessment. At the time of surgery, the anesthesiologist was responsible for the set-up of the VRH device. The head-mounted goggles (Samsung Gear VR R323 by Oculus) and appropriate headphones (Sennheiser HD400s) were placed after patient positioning and preparation of the sterile field (figure 1). The VR program (Aqua Module Dutch version 4.0, Oncomfort™ SA, Wavre, Belgium) was initiated after reviewing the instructions with the patient. This program creates a simulation of diving into an undersea environment (http://www.oncomfort.com/en). In the surroundings of this VR world, the patients experience a lively illusion where they are challenged with the idea of existing in this simulation. These are principles of the feeling of immersion and the sense of presence, although this has not been validated through studies for this equipment. On top of this, clinical hypnosis is given through an audio script which gives continuous suggestions for progressive muscle relaxation, deep breathing and wellbeing. Patients are being guided into a relaxed state of heightened focus and concentration in order to alter the patient's pain experience. The patient from case 1 gave no indication of pain and scored this as a 1 out of 10 on a numeric rating scale (NRS) perioperatively. When asked, he was comfortable during surgery and confirmed his satisfaction with the use of VRH. The patient from case 2 asked if the HMD and headphones could be removed 90 minutes after the incision because the program had ended. At this point he felt he no longer needed the VR device. After removal of the headset, the pressure of the tourniquet started to cause discomfort. He reported to become more aware of the operation through movement of his arm and the loud sounds of the drilling and hammering. After recovery and rehabilitation, this patient planned to have his right elbow operated as well. When asked if he would opt for RA supplemented with VRH for the following procedure, he responded positively.

Figure 1. Setup of a patient with the virtual reality goggles and headphones behind the sterile field (case 1).

Discussion

We investigated the concept of applying a combination of virtual reality and hypnosis in a medical setting and more specifically during RA for upper limb surgery. The concept of distraction with a VR device has already been successfully investigated in a study of 9 patients that underwent orthopedic surgery of the lower limbs (12). These patients were treated with VRD that was guided by audiphones playing classical music. They did not receive hypnosis, but the results demonstrated the beneficial potential of a VR device in the setting of an operating theatre. Both patients in current case report received VRH, which is a combination of a visual immersion in a VR world while at the same time listening to a hypnotic script that induces relaxation through focused attention. Both techniques strive to achieve a similar goal which is to diminish negative and painful perceptions. It has been suggested that VR has the potential to aid hypnotic interventions by guiding someone with the visualization process (18). Patients might find comfort with an immersive visual assistance when given clinical hypnosis. Hypnosis is a beneficial technique, but there are some factors limiting widespread use. It is a one on one intervention, making it a challenge when there is limited medical personnel with sufficient hypnosis training. It is unilingual and patient and medical personnel could be prejudiced. In literature it has been documented as an alternative means for pain management (19-22). It induces dissociation between pain sensation and the emotional component of the pain experience (23). The patients pass into a hypnotic state through focused attention. Clinical hypnosis reduces involuntary movements, stabilizes vital signs and

results in reduced subjective peripheral awareness and time distortion (24). It is currently considered as a well-established treatment for acute and chronic pain (22). Enea et al. emphasized the difference between someone who is highly hypnotizable and someone who is low hypnotizable (25). To assess for a patient's hypnotizability level they used the Harvard Group Scale of Hypnotic Susceptibility, Form A. In their study it was shown that both types of persons (high and low hypnotizable) responded well to VRH. Hypnosis susceptibility was not investigated in our patients prior to surgery.

Distraction through VR (VRD) without hypnosis is an effective technique. It provides an increase in general insensibility to pain without diminishing consciousness (26). One study reported a significant decrease in the administered doses of fentanyl and midazolam when VRD was applied during preoperative perineural catheter insertion (8). Such an analgesic effect with VRD is also supported by a study of Hoffman et al (9). With the aid of functional magnetic resonance imaging and a non-ferromagnetic VR helmet, lower pain-related brain activity was observed in the regions of the insula, secondary somatosensory cortex (SS2) and thalamus during a thermal pain stimulus. These neuroanatomic regions are a part of the 'pain matrix' and become metabolically active during nociceptive stimulation when subjects report subjective pain. A combination of opioids and VRD was more effective than opioids alone or VRD alone. The authors recommend a multimodal analgesic approach. Such a strategy was used in our cases as RA is combined with VRH. More specifically, VRH itself adheres to such a multimodal approach as it combines VRD and clinical hypnosis, both independent analgesic techniques.

Our two case reports support the use of VRH with RA in the safe environment of an operating theatre where continued monitoring by well-trained medical staff and the resources for urgent intervention, if necessary, remain constantly available. The technology of Oncomfort ™ uses a HMD and separate headphones for VRH. These devices are all retrieved from a single kit which holds an instruction manual in different languages. This setup was well tolerated by the patient and the operating staff, and did not interfere with the surgery. The additional time required for installation of the VRH device was negligible, considering the anesthesiologist was experienced with the instructions. The HMD and respective phone were disinfected before and after usage to promote a sterile environment. The patient could interact with the anesthesiologist at any time during the procedure. The responsibility of providing VRH belongs to the anesthesiologist who should be aware of its functionality at all time during surgery. With a HMD however, it is difficult to assess whether the patient is asleep or engaged with the VRH. This has already been indicated by Chan et al (12). As yet it is uncertain whether integrated electro-encephalogram monitoring might aid in evaluating the depth of sedation. Our two patients demonstrated excellent cooperation with the HMD and reported to be awake during the entire length of surgery. The anesthesiologist regularly checked the positioning of this device and its activity. A single congress abstract describes the use of VR with a HMD as a preferred method by patients in comparison to standard retrieval conditions in which no devices are used (5). Another study compared VRD with video in a population of patients that received painful dental procedures (6). They noticed that there was a preference for a VR-device as opposed to a video. It should be noted that certain contra-indications are listed by Oncomfort™ : deafness or poor hearing, severe visual impairment, wounds or infections on the head, severe cognitive, behavioral or anxiety disorders, or phobia for water or sea. Our patients did not exhibit such traits.

Both patients underwent procedures under RA without receiving sedative-hypnotic medication. They remained calm and motionless, so surgery and aseptic technique were not comprised at any time. The orthopedic surgical stimulation (hammering, pneumatic drilling and prosthesis placement) did not disturb the patients while wearing the HMD. Side effects of sedative-hypnotic medications were avoided in these high-risk patients with this non-pharmacological approach. They remained hemodynamically stable and showed no signs of respiratory depression. A study by Moon et al. investigated the incidence of apnea between a group receiving VRH and a another group receiving sedation with midazolam (15). They reported a significant lower incidence of apneas in the VRH group. Sedation with intravenous midazolam is known to cause respiratory depression and patients with COPD are at high risk for this side effect (27, 28). Therefore, the possibility of such adverse drug effects was eliminated in both our cases. A recently published study has even researched the possibility of music medicine as an alternative for midazolam during the preoperative placement of nerve blocks (29). These results require further investigation but such studies demonstrate the ongoing pursuit for better non-pharmacological approaches to reduce

anxiety and improve analgesia during painful procedures.

VRH is an innocuous technology that, as an effective analgesic intervention, can be used as a cost-effective treatment. Anesthesiologists still remain diffident to this new technology, and it is not commonly proposed to patients. A reported benefit of VRH is the higher satisfaction for both the anesthesiologist and the patient (15). Careful assessment of each patient is of importance before applying VRH. An important prerequisite for success is to have a patient that is motivated to use this approach. Information regarding the application of VRH should be given during a preoperative assessment. This promotes shared decision making and allows the patient to give informed consent. Such technology can encourage patients, in particular high-risk patients, to agree to RA. They can find comfort in the combination of hypnosis and distraction during long-lasting procedures.

In conclusion, we report our experience with VRH as an effective non-pharmacological method for improving patient comfort during prolonged upper limb orthopedic surgery with RA. A principle advantage of this technique is the avoidance of sedative-hypnotic medication, which might otherwise compromise cardiorespiratory stability, especially in high risk patients. Patient comfort and satisfaction can be assured. The technique should be discussed with the patient when consent for an RA technique is being proposed. We suggest that further randomized controlled trials should be performed to investigate these encouraging findings.

Acknowledgement

Al data were collected at the Antwerp University Hospital.

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