Virtual Reality Improves the Patient Experience during Wide-Awake Local Anesthesia No Tourniquet Hand Surgery: A Single-Blind, Randomized, Prospective Study

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Summary: Wide-awake local anesthesia no tourniquet surgery has been shown to decrease cost and hospital length of stay. The authors studied the use of virtual reality during wide-awake local anesthesia no tourniquet outpatient upper extremity surgery to assess its effect on patient pain, anxiety and fun. Patients undergoing wide-awake local anesthesia no tourniquet surgery were randomized to use (virtual reality) or not use (non–virtual reality) virtual reality during their procedures. Pain, fun, and anxiety were measured with a Likert scale at several time points, as were blood pressure and heart rate. A postoperative questionnaire was used to assess overall satisfaction. Virtual reality patients exhibited lower anxiety scores during injection, during the procedure, and at the end of the procedure. There were no differences in blood pressure, heart rate, or pain scores. Compared with non–virtual reality patients, virtual reality patients' fun scores were higher. Virtual reality patients felt the experience helped them to relax, and they would recommend virtual reality–assisted wide-awake local anesthesia no tourniquet surgery. Among patients with self-reported preexisting anxiety, virtual reality patients had lower pain and anxiety scores during injection of local anesthesia compared with non–virtual reality patients. This study demonstrates that readily available virtual reality hardware and software can provide a virtual reality experience that reduces patient anxiety both during the injection of local anesthesia and during the surgical procedure. (*Plast. Reconstr. Surg.* 144: 408, 2019.)
CLINICAL QUESTION/LEVEL OF EVIDENCE: Therapeutic, II.

It can take decades for medical technological advances to become adopted. Based on the nineteenth century stereoscope,[1] a commercial example of virtual reality was first developed by Sega in the early 1990s. Now, in the twenty-first century, virtual reality technology has come of age. In 2016, Goldman Sachs predicted that the use of virtual reality in medicine would be the second largest area of business growth for the virtual reality industry by 2025.[2]

At Michigan State University, we offer wide-awake local anesthesia no tourniquet surgery to our upper extremity surgery patients based on the pioneering work of Donald Lalonde, M.D.[3] We hypothesized that the patient experience might be improved by the introduction of virtual reality. To date, there are no publications demonstrating the use of virtual reality perioperatively to enable wide-awake local anesthesia no tourniquet surgery. In addition, there are relatively few publications on the clinical use of virtual reality technology during any surgical procedures. According to the research that does exist, Walker et al.[4] did not identify a difference between their virtual reality group and their control group when performing cystoscopy. Mosso et al.[5] found that virtual reality reduced anxiety levels for patients undergoing ambulatory operations under local or regional anesthesia. These operations included

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hernia repairs under regional anesthesia, and minor tumor resections under local anesthesia. Virtual reality has also been demonstrated to be effective in awake patients undergoing many other types of uncomfortable procedures, including chemotherapy administration,[6–11] pediatric needle-stick punctures,[12,13] burn care in children and adults,[14–20] and dentistry.[21–25]

PATIENTS AND METHODS

All patients treated by the senior author (J.H.W.C.) and undergoing routine wide-awake local anesthesia no tourniquet hand operations in an office procedure room at Michigan State University Department of Surgery were invited to participate in the study (Fig. 1), provided they did not meet exclusion criteria. Data collection took place over a 6-month period.

Approval from the Michigan State University Biomedical and Health Institutional Review Board was obtained before enrolling patients. After obtaining written informed consent, patients were randomized to those receiving virtual reality (virtual reality) and those not receiving virtual reality (non–virtual reality) by envelope selection.

A Samsung (Seoul, Republic of Korea) Galaxy S7 phone and a Samsung Gear virtual reality headset with headphones, which represent readily available and inexpensive technology, were used. The hardware was coupled with freely available media from YouTube.

All patients received tumescent local anesthesia with lidocaine and epinephrine by the same surgeon using the technique described by Lalonde and Wong.[26] For the virtual reality patients, this was performed while watching a specifically selected video in which the injection was timed to coincide with a moment of catharsis in the virtual reality experience ("Evolution of verse" https://www.with.in/watch/evolution-of-verse/.) This moment of relief occurs as an oncoming train dissipates into a flock of starlings the second before it collides with the viewer.

During the procedure, each virtual reality patient selected from a choice of freely available 360-degree YouTube materials that were previously recorded on the equipment. This immersive three-dimensional material included viewing historical cities, rivers, landscapes, or underwater ocean experiences.

Prospective Data Collection and Analysis

Data were collected prospectively at multiple time points: during anesthetic injection (injection), midway through the procedure (mid-procedure), and at the end of the procedure in a recovery environment (end). At each time point, data collected included heart rate and mean arterial blood pressure, and a 10-point Likert scale assessing anxiety, pain, and fun (0 = least anxiety, pain, and fun; and 10 most anxiety, pain, and fun). Postoperatively, all patients were asked to rate how much they enjoyed their surgical experience on a 10-point Likert type scale (0 = least and 10 = most). Virtual reality patients were queried, also, about symptoms of cybersickness (nausea, dizziness, vomiting) and the degree to which virtual reality helped them relax and whether they would recommend virtual reality to other patients.

Data were analyzed using unpaired t tests. A value of $p \leq 0.05$ was considered significant.

Fig. 1. Patient using virtual reality while undergoing routine wide-awake local anesthesia no tourniquet hand surgery.

Table 1. Patient Demographics and Self-Reported Prior Medical Conditions

	VR Group	Non-VR Group
No.	21	20
Age range, yr	20–82	38–82
Sex, %		
Male	57	30
Female	43	70
Ethnicity		
White	17	17
Black	3	0
Hispanic	2	1
Other	1	2
Prior medical conditions*		
Stroke/CVA	2	2
Diabetes	6	8
Anxiety disorder	4	7
Depression	4	7
Claustrophobia	1	7

VR, virtual reality; CVA, cerebrovascular accident.
*Prior medical conditions were self-reported.

RESULTS

Group Demographics, Medical History, and Case Mix

Exclusion criteria included history of seizures, pacemaker, vertigo, allergy to plastic, severe nearsightedness/far-sightedness, and unwillingness to wear bands around the head. Patient demographics and self-reported prior medical conditions are listed in Table 1. Types and durations of procedures are listed in Table 2.

Heart Rate and Blood Pressure

There were no significant differences between the virtual reality and non–virtual reality groups with respect to heart rate or mean arterial blood pressure at any of the measured time points.

Anxiety, Fun, and Pain

Scores for anxiety and fun, but not for pain, were significantly different in virtual reality versus non–virtual reality patients at each time point (Fig. 2). Because anxiety is one of the major reasons patients are dissuaded from wide-awake surgery, we separately analyzed the patients with self-reported anxiety disorder to see whether virtual reality is useful in reducing anxiety in these patients. Among patients with preexisting anxiety, use of virtual reality achieved a statistically significant decrease in anxiety during the procedure. At both time points, during and at the end of the procedure, anxiety levels were comparable to those seen in patients without preexisting anxiety (Fig. 3). Among patients with preexisting anxiety, pain scores during the injection phase were significantly lower in the virtual reality compared with the non–virtual reality group and were comparable to the scores of patients without preexisting anxiety (Fig. 4).

Postprocedure Questions

Likert score answers to the question, "How much did you enjoy your experience today?" showed that virtual reality patients enjoyed their experience more than non–virtual reality patients, 8 of 10 compared to 3 of 10, respectively ($p < 0.01$). Over 80 percent of virtual reality patients reported that virtual reality was a good experience, it helped them relax, and they would recommend it. The patient who disagreed that the virtual reality experience was good and disagreed that she or he would recommend it was older than 82 years and represented the oldest individual in the virtual reality group.

Table 2. Procedures and Durations

Procedure	Group	No.	Duration of Procedure (min)
Carpal tunnel release	VR	7	18–27
	Non-VR	11	11–25
Forearm scar revision	VR	1	35
	Non-VR	1	63
Kirschner wire phalanx or metacarpal	VR	2	14–33
Buried Kirschner wire removal	VR	2	8–19
Thumb IPJ capsulotomy	VR	1	13
Mucous cyst right thumb	VR	1	10
Carpal tunnel and trigger finger release	VR	2	15–23
Zone 2 trigger finger release	VR	1	31
Excision palmar schwannoma	VR	1	10
Double trigger finger release	VR	1	20
Zone 2 flexor tendon repair	VR	1	24
Tenolysis and capsulotomy	Non-VR	2	20–39
Digital nerve repair	Non-VR	1	17
Carpal tunnel release and excision of mucous cyst	Non-VR	1	15
Mucous cyst ring finger with local flap	Non-VR	1	20

VR, virtual reality; IPJ, interphalangeal joint.

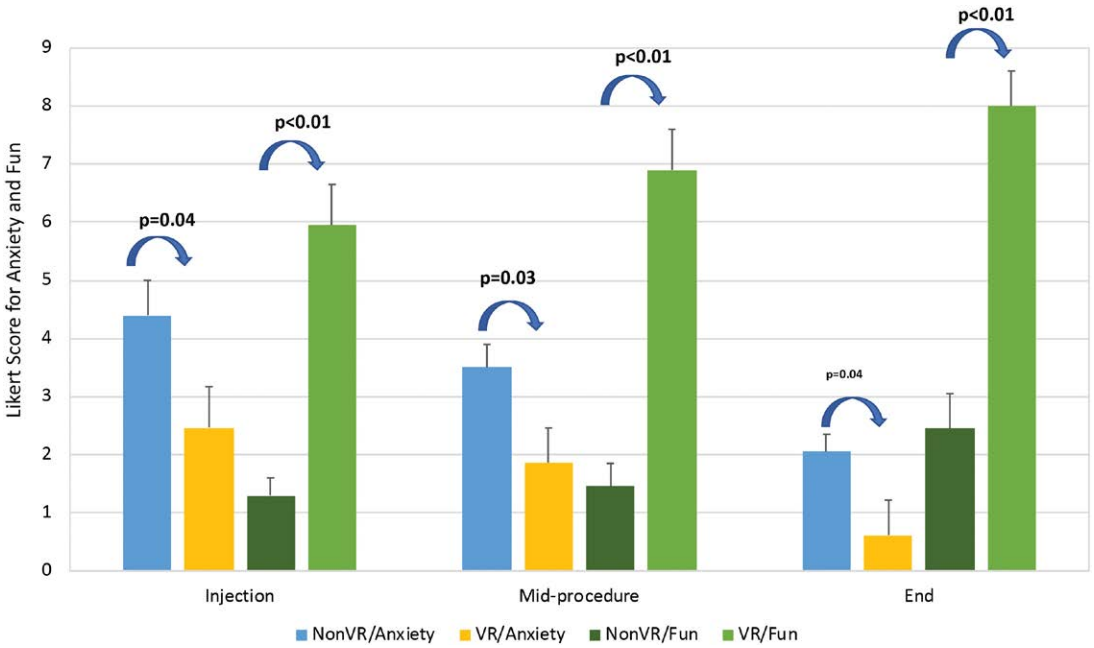

Fig. 2. Comparison of anxiety and fun scores between patients using virtual reality (*VR*) and those not using virtual reality (*nonVR*) (mean ± SEM).

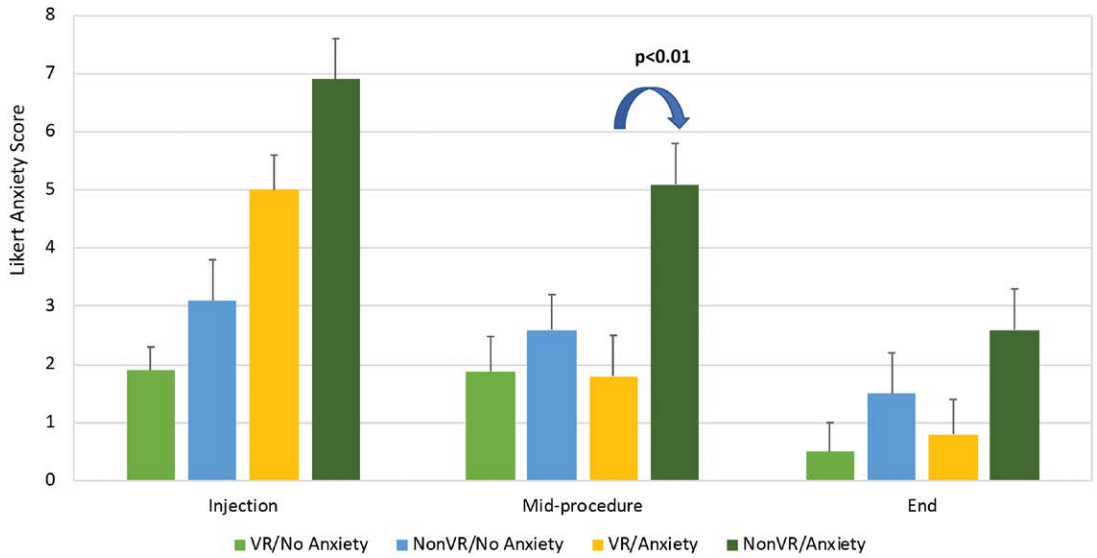

Fig. 3. Comparison of anxiety scores between patients using virtual reality (*VR*) and those not using virtual reality (*nonVR*) among patients with reported preexisting anxiety (mean ± SEM).

Among virtual reality patients, three experienced dizziness, two reported nausea, and none reported vomiting. Patients' comments regarding virtual reality technology were also recorded (Table 3).

DISCUSSION

This study suggests the patient experience of wide-awake local anesthesia no tourniquet surgery is enhanced by virtual reality. Many patients are not comfortable with the idea of undergoing wide-awake surgery, even though wide-awake local anesthesia no tourniquet surgery is a more convenient, more safe, and more cost-effective option for many upper extremity surgical procedures.[3] Coupling wide-awake local anesthesia no tourniquet surgery with virtual reality may increase the likelihood that patients will select the office

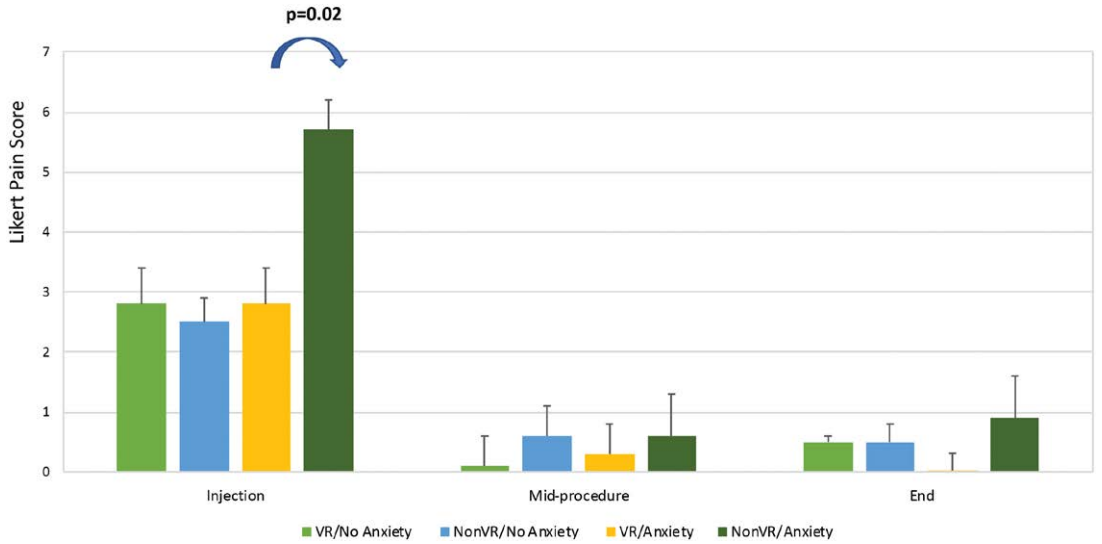

Fig. 4. Comparison of pain scores between patients using virtual reality (*VR*) and those not using virtual reality (*nonVR*) among patients with reported preexisting anxiety (mean ± SEM).

Table 3. Postprocedure Comments from Virtual Reality Patients

"It's really fun."
Patient felt videos were boring. Patient did not speak English so data were collected through sister as a translator.
"I would recommend everyone use this during surgery."
"I felt dizzy during ocean scene."
"It's actually really fun."
"I wanted to watch the procedure."
"Definitely helping."
"You guys need better video quality."
Patient would have preferred to talk with the surgeon and watch procedure.
Volume was too loud and patient wanted better video quality.
Patient wanted to speak with surgeon during the procedure. Patient also felt VR was very relaxing.
Patient felt VR was absolutely great.
Patient felt it was much fun but after a period of orientation.
"That thing was really fun."

procedure room as the location to undergo their surgery.

This study suggests also that virtual reality may be of particular help during administration of local anesthesia. Synchronizing the moment of needle puncture with an experience of relief within the virtual reality environment may dissociate the patient from the discomfort of the procedure. Virtual reality may therefore have applicability to procedures performed in the emergency department, and bedside procedures in the in-patient setting.

We found few disadvantages to using virtual reality. Although cybersickness has been reported in the literature, we did not observe significant levels in our study.[27–29]

As pointed out by Lalonde, physician-patient interaction may provide an opportunity for education and allow interaction to assess surgical hand function.[3] Concern could be raised that this interaction is compromised by the virtual reality experience. We found that our virtual reality patients' cooperation with perioperative instructions to move the hand and arm was easy and immediate.

Virtual reality may not be helpful for all patients. The dissatisfaction that an 82-year-old patient reported suggests that virtual reality may be less suitable for individuals who may be unfamiliar with this technology. One patient reported preference for communicating with the surgeon rather than wearing the virtual reality device. We could not use virtual reality reliably on five occasions because of overheating of the Galaxy S7; this model is already superseded at the time of publication. Thus, we were unable to obtain data on the aforementioned five patients.

One patient in the virtual reality group had previously used virtual reality technology. This study thus reflects the reactions of patients for whom this technology is a novelty.

The virtual reality experience should be personalized. One patient reported disliking the content because she or he was water phobic and the media included several underwater diving experiences. Currently, there are few recordings of 360-degree panoramic virtual reality–formatted media matching the duration of a typical operation. Thus, there is a need for the industry to expand and diversify the available content to provide patients a wider selection of choices.

As technology progresses, it may be possible for patients not only to experience the benefits of distraction by virtual reality, but also to view and interact with their operation in real time. Augmented reality can reduce the potentially alarming experience of looking at the hand during surgery. In addition, by using augmented reality, the patient may be able to follow visual guidance for hand functions to assist with procedures such as tenolysis and tendon transfer.

CONCLUSIONS

This study demonstrates that readily available virtual reality hardware and software can be used to provide a passive and immersive experience that reduces patient anxiety both during the injection of local anesthetic and during surgical procedures. Our experience also reflects that the technology is still occasionally unreliable. Because virtual reality may be of particular help during administration of local anesthesia, virtual reality may have wider application to procedures performed in the emergency department, and bedside procedures in the in-patient setting.

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