Randomized Clinical Study

Ultrasound-Guided Regional Anesthesia Using a Head-Mounted Video Display: A Randomized Clinical Study

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Background: Ultrasonography is increasingly being used in every field of medicine, especially regional anesthesia. To successfully perform the procedure, a knowledge of anatomy and ultrasonoanatomy as well as technical 3D hand-eye coordination skills are required. Medical practitioners who use ultrasound devices to perform regional blocks have to correlate the position of the ultrasound probe on the patient, needle position, and ultrasound picture. To achieve that, the practitioner has to intermittently look between the patient and the ultrasonography screen. This requires extra head rotations, increasing the time and complexity of the procedure. Newer technologies are available that can alleviate the need for these extra head movements, such as head-mounted displays (HMDs), which are connected to the ultrasonography machine and project the ultrasonography picture onto the HMD goggles so that the provider can see the monitor without unnecessary head rotations.

Objective: Our theory was that the use of the HMD goggles would decrease the overall procedure duration as well as provider head rotations.

Study Design: This was a randomized clinical study.

Setting: The research was conducted at an academic medical center at the University of Texas Medical Branch, Galveston, TX.

Methods: We secured Institutional Review Board (IRB) approval to perform the study. We chose an HMD, which can be mounted on the head like regular goggles. By connecting the HMD with the ultrasonography machine, the ultrasound picture can be projected directly in front of the physician's eyes. Twenty-four patients were randomized to receive a regional anesthetic performed by anesthesiology residents using a conventional ultrasound-guided approach or using the HMD in addition. We measured the number of attempts, head rotations, and time needed to obtain a satisfactory nerve stimulation in addition to outcomes and adverse effects. Our data were interpreted by our statistician with $P < .05$ indicating statistical significance.

Results: Regional anesthetics performed with the HMD were significantly faster (59.08 vs 175.08 seconds) with significantly fewer head movements (0.83 vs 4.75) and attempts (1 vs 1.42). There were no significant differences in patient demographics, type of regional anesthetic, level of resident training, or outcomes. No complications were noted.

Limitations: A limitation of our research is that neither observers nor providers were blinded to the way blocks were performed. This would have been practically impossible because participants had to wear an HMD.

Conclusions: The HMD could provide advantages in regional anesthesia by decreasing the time and attempts and improving ergonomics. These findings can be easily translated into other ultrasound- or optic/camera-guided procedures outside of regional anesthesia, such as vascular access or laparoscopic surgery.

IRB: UTMB IRB #12-143

Key words: Head-mounted video display, nerve blocks, randomized clinical study, regional anesthesia, regional blocks, ultrasound, vascular access

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Numerous technological advances are changing the field of regional analgesia and anesthesia. Ultrasound guidance during many nerve block procedures is increasingly prevalent, and growing evidence supports its use (1).

To successfully perform this procedure, knowledge of anatomy and ultrasonoanatomy as well as technical 3D hand-eye coordination skills are required. Medical practitioners who use ultrasound devices to perform regional blocks have to correlate the position of the ultrasound probe on the patient, needle position, and ultrasound picture. To achieve that, they have to intermittently look between the patient and the ultrasonography screen. This requires extra head rotations, increasing the time and complexity of the procedure. Furthermore, these head rotations could distract the physician, potentially interfering with their grip on the ultrasound probe, ultimately losing the image of the target structure.

Newer technologies are available that can alleviate the need for these extra head movements, such as head-mounted displays (HMDs). These devices are connected to the ultrasonography machine and project the ultrasonography picture onto the HMD goggles so that the provider can see the monitor without unnecessary head rotations between the patient and the ultrasonography machine (2,3).

Our theory was that the use of HMD goggles would decrease the total procedure duration as well as provider head rotations in a randomized clinical study. We initially performed the study using the Blue Phantom (CAE Healthcare, Sarasota, FL) to simulate an extremity for a peripheral, ultrasound-guided nerve block (4). We selected 20 providers with varying levels of procedural and ultrasound skills and training and instructed them to complete a regional nerve block with ultrasonography with and without the HMD. We measured the number of attempts, head rotations, and time needed to obtain a needle position. We analyzed the data with a t test and considered $P < .05$ statistically significant.

According to our results, providers accomplished regional blocks faster with the HMD than without it (7.1 vs 10.9 seconds). In addition, the HMD drastically decreased the number of ultrasonography probe manipulations and head rotations. These findings indicated that the HMD improved the efficiency of simulated regional blocks and that clinical studies were warranted. Based on that, in our current research we sought to determine if our results with the HMD in a simulated environment could be translated to complex clinical settings in regional anesthesia.

Methods

We secured Institutional Review Board approval at our academic medical center (University of Texas Medical Branch) to perform the study. We pulled an envelope to randomize 24 patients, half of whom received a regional anesthetic performed by anesthesiology residents using a conventional ultrasound-guided approach and half of whom received regional anesthetic from residents using ultrasound and an HMD (Fig. 1). Anesthesia residents (CA-2) who were on their initial regional anesthesia rotation participated. They simulated blocks with the Blue Phantom (5 blocks with the HMD, 5 blocks without the HMD) before using the HMD on patients.

Our institution purchased the HMD (Wrap Trade Mark Video Eyewear, Vuzix Corporation, Rochester, NY), which is a binocular image monitor fitted to the face like regular goggles. The ultrasound machine (SonoSite, Bothell, WA; Fig. 2) image was then translated onto the HMD in front of the provider's eyes. A 13-6 MHz probe was used.

We performed all regional blocks using an in-plane approach with a 21-gauge, 50-mm Stimuplex needle with a 30° bevel (Braun Medical Inc., Bethlehem, PA).

The ultrasound machine was placed on one side of the patient, opposite to the provider, unless an HMD was used. In that case, the ultrasonography machine was hidden behind the provider to remove a potential distraction and the bias created by the operator's reliance on the ultrasonography screen rather than the HMD image. A designated observer recorded the time from the visualization of the target nerve in the patient and skin perforation until the target nerve was touched with the needle tip, causing stimulation. Another designated observer measured the ultrasonography probe and head rotations of the providers. The same position was maintained for all providers throughout the entire study. Adjustments of the ultrasonography probe (such as movement of the probe to reacquire the picture of the needle or target nerve) were noted and rotations of the head > 45° (either rotation or extension/flexion) were counted. We measured the number of attempts, head rotations, and time to acquire a satisfactory nerve stimulation in addition to outcomes and adverse effects.

We analyzed the data with a t test and considered $P < .05$ statistically significant.

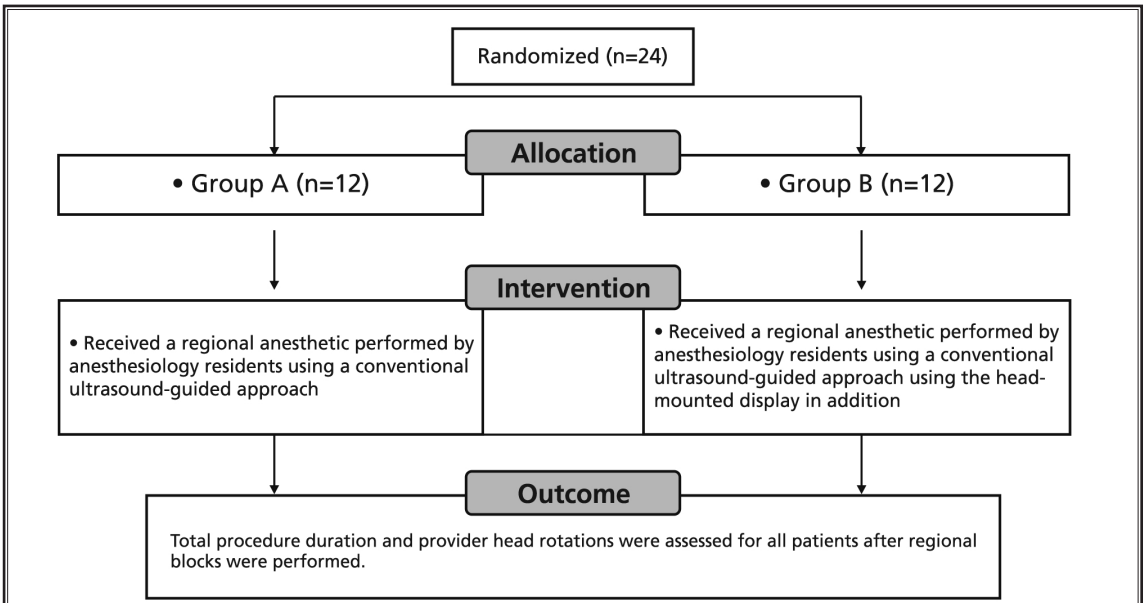

Fig. 1. *Flow chart of the study's design.*

Results

Regional anesthetics performed with the HMD were delivered significantly faster than with the conventional ultrasound-guided approach ($P < .05$; mean: 59.08 vs 175.08 seconds; standard deviation [SD]: 42.46 vs 171.51; Fig. 3). There were significantly fewer provider head movements with the HMD ($P < .05$; mean: 0.83 vs 4.75 head movements; SD: 0.83 vs 2.30; Fig. 4) and attempts ($P < .05$; mean: 1 vs 1.42 attempts; SD: 0 vs 0.52; Fig. 5). There were no significant differences in patient demographics (Table 1), type of regional anesthetic (Table 2), level of resident training, or outcomes. No complications were noted.

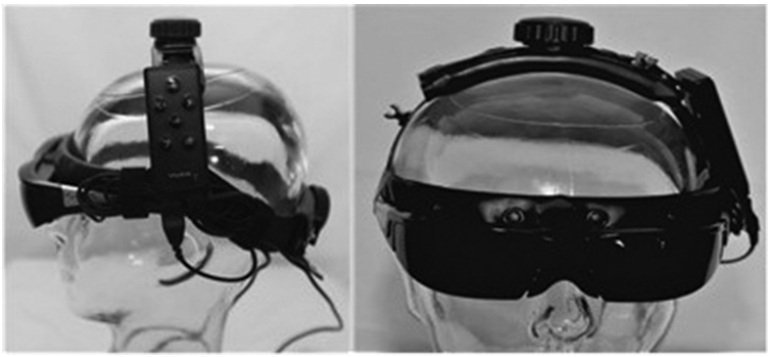

Fig. 2. *Head-mounted video display lateral and frontal view.*

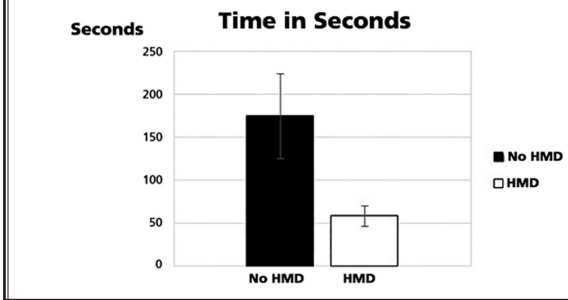

Fig. 3. *Time in seconds. Statistically significant with $P < .05$; data in mean and standard error of the mean.*

Discussion

The HMD could provide advantages in regional anesthesia by decreasing the time and number of attempts and by improving ergonomics. These benefits can be easily translated into other ultrasound- or optic/camera-guided procedures performed by any ultrasonographer outside of regional anesthesia, such as vascular access or laparoscopic surgery or radiology and cardiology.

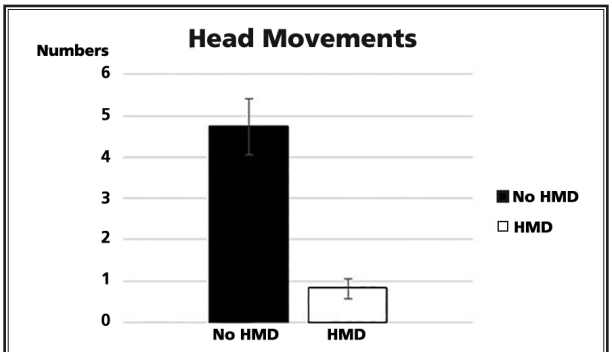

Fig. 4. *Head movements. Statistically significant with P < .05; data in mean and standard error of the mean.*

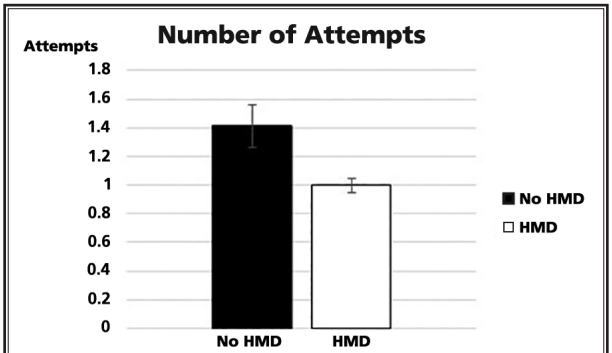

Fig. 5. *Number of attempts. Statistically significant with P < .05; data in mean and standard error of the mean.*

Table 1. *Patient demographics*

Demographics	No HMD (mean ± SD)	HMD (mean ± SD)
Number of patients	12	12
Age (yrs)	55 ± 22	65 ± 10
Gender (male/female)	4 of 8	3 of 9
BMI	29 ± 8	31 ± 8
ASA class	2	2
Upper/lower extremity blocks	3 of 9	3 of 9

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; HMD, head-mounted display; SD, standard deviation.

Table 2. *Regional anesthesia demographics*

Type of RA	HMD	Without HMD
Interscalene	2	2
Axillary	1	1
Femoral	7	5
Popliteal	2	4

Abbreviations: HMD, head-mounted display; RA, regional anesthetic

Sites et al (5) used a detailed video analysis of performances of ultrasound-guided regional blocks by 6 anesthesia residents during a dedicated 1-month rotation. They performed 520 regional blocks with 398 errors committed. The 2 most common errors were failure to visualize the needle before advancement (43.7%) and unintentional probe movement (26.9%). Lack of needle visualization leads many less-experienced operators to use the probe to find their needle, which causes loss of target visualization, forcing further intentional probe movement in efforts to reimage the targeted structure. Unintentional ultrasonography probe movement is a sign of poor hand-eye coordination. Poor ergonomics and awkward hand position most likely contributed to the unintentional probe movement because 70% of the cases of poor ergonomics also had at least one episode of unintentional probe movement. Altogether, up to 39.9% of all combined errors might be related to problems with hand-eye coordination, which is supported by the fact that these types of mistakes decrease with provider experience (5).

In our current study, we demonstrated that an HMD of the ultrasonography image improves efficiency and ergonomics, similar to what we demonstrated in our simulated nerve block study (4). Head rotations and ultrasonography probe adjustments were significantly decreased with the video goggles and the duration of the blocks was significantly shortened compared to the classical way of performing nerve blocks. The HMD could eliminate up to 40% of all mistakes observed by Sites et al.

A limitation of our research is that neither observers nor providers were blinded to the way blocks were performed. Practically speaking, this would have been impossible because participants had to wear an HMD.

We acknowledge that setting up HMD goggles by connecting them with cables to the ultrasonography machine required some extra set-up time in the beginning, but this can be addressed by using wireless technology in the future. Wireless technology could help in using limited regional block areas in a more ergonomic way for providers as well.

Author Contributions

Drs. Przkora and Solanki had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. Drs. Przkora and Solanki designed the study protocol. Drs. Przkora, Solanki, Mora, Balduyeu, and Meroney managed the literature searches and summaries of previous related work and wrote the first draft of the manuscript. Drs. Meroney, Mora, Vasilopoulos, and Balduyeu provided revision for intellectual content and final approval of the manuscript.

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