Immersive Virtual Reality for Pain Control and Anxiolysis During IV Blood Draws in Adults: A Randomized Controlled Trial

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ABSTRACT

Objective:
To evaluate immersive virtual reality’s (IVR) effectiveness as a distraction in reducing perceived pain and anxiety among adults undergoing intravenous (IV) blood draw.

Methods:
In this randomized controlled trial, we recruited adult patients 18-50 years of age scheduled for routine blood draws at the phlebotomy lab and randomized them into experimental and control groups. The experimental group underwent IV blood draw with IVR, and the control group underwent IV blood draw with standard practice. Before the procedure, subjects rated their anxiety level and the pain they “expected” to experience during blood draw. Immediately afterward, the subjects rated their actual “perceived” pain level. We measured the “expected” and the “perceived” pain and anxiety scores using a 100 mm visual analog scale. The primary outcome was the difference in “perceived” pain scores (0-100) between the two cohorts. Secondary outcomes were differences between the anxiety scores and the “expected” and “perceived” pain between the two cohorts, as well as degree of satisfaction with IVR during the blood draw and willingness to use IVR in future procedures.

Results:
Fifty-nine subjects completed the study, 31 in the experimental group and 28 in the control group. For the primary outcome, the control group reported a perceived median pain score of 6.5 vs. the experimental group of 5; \( P = .55 \). For the secondary outcomes, the median anxiety scores were 22 (6.25-45.75) and 24 (2.00-35.00) for the control and the experimental groups, respectively, \( P = .44 \). The control group reported an expected median pain score of 20 vs. a perceived score of 6.5; \( P = .25 \), and the experimental group reported an expected median pain score of 22 vs. a perceived score of 5; \( P < .01 \). Median Likert scores were 5 (1-5) for satisfaction and preference for future use during painful procedures.

Conclusions:
The results of our study demonstrated that there was no significantly lower perceived pain or anxiety when using IVR compared to standard practice in adults undergoing IV blood draw.

INTRODUCTION

Intravenous (IV) catheter insertion and IV blood draws are essential procedures in emergency medical care, medical readiness screening, and deployed medicine. In an Australian study, approximately 15% of patients presenting to the emergency department (ED) received IV access.\(^1\) Department of Defense regulations require that all service members undergo a blood draw at least once to retain a DNA sample on file, as well as human immunodeficiency virus testing every 2 years.\(^2\)

Additionally, depending on age, risk factors, and flight status, service members may be required to undergo more frequent testing for lipid abnormalities, diabetes screening, tuberculosis, and other health hazards.

This procedure is unpleasant and causes pain and anxiety for many patients. Clinicians have explored several pharmacologic agents to lessen the discomfort caused by IV insertion.\(^3\) However, these agents may increase the length of an ED stay and are associated with unwanted side effects. For example, lidocaine/prilocaine cream (EMLA) is ineffective when applied for 20 minutes or less\(^5\) and frequently causes pruritis and urticaria.\(^6\) Intradermal injection of local anesthetics has also been studied. However, this technique is also associated with discomfort.\(^4\)

Novel techniques for procedural pain control, such as distraction, are being explored as alternatives to pharmacologic therapy.\(^7\) Immersive virtual reality (IVR) as a distraction strategy may be an alternative to pharmacologic therapy for reducing the discomfort associated with IV insertion. These IVR devices are highly portable (not requiring continuous internet access) and quickly deployable for use during minor
procedures. A systematic review of 17 studies demonstrated this technique as safe and efficacious in reducing the pain pediatric patients perceived when undergoing venipuncture. However, few studies exist evaluating IVR technology as a distraction method to assist with pain and anxiety in adults undergoing venipuncture, and the persons performing blood draws are rarely blind to treatment conditions.

During IVR, the patient sees distracting visual stimuli instead of the venipuncture. Even when they are turned off, virtual reality (VR) goggles may still help decrease procedure-related anxiety because the occlusive goggles block the patient’s view of the procedure. The current study is one of the first to compare two conditions involving the use of a VR helmet (active VR helmet compared to a VR helmet that is turned off). This methodology helps keep the phlebotomist blind to the treatment group, reducing the risk of bias.

This study aims to evaluate the efficacy of IVR in reducing pain in adults undergoing IV blood draws. The primary outcome is the difference in self-reported pain score (0-100 using a visual analog scale [VAS]) between patients undergoing IV blood draw while using IVR as a distraction technique and those undergoing standard practice. Secondary outcomes include comparing the difference in self-reported anxiety scores between the two cohorts and comparing the anxiety the subjects expected to experience vs. what they experienced. We also assessed subjects’ satisfaction with using IVR during blood draws and their willingness to use IVR during future procedures if available.

If the results of this study show a clinically significant reduction in adult subjects’ pain and/or anxiety scores, it would be reasonable to consider further research exploring the use of IVR for distraction during other commonly performed ED and clinical procedures, such as laceration repair, nail trephination, nail removals, lumbar punctures, and incision and drainage of abscesses. Additionally, these results could be relatable to other practice settings, including laboratory, family practice, or deployed military environments.

METHODS AND MATERIALS

Study Design

We conducted this prospective randomized controlled single-blind trial in the phlebotomy lab at an Army community hospital. The Regional Health Command-Central Institutional Review Board approved the study protocol (reference number C.2020.0610). Once the protocol was approved, we engaged with the laboratory leadership to arrange a suitable time-frame for data collection. We also registered the study with ClinicalTrials.gov (trial number NCT04449341).

Study Population

Adult patients scheduled to undergo blood draw in the phlebotomy lab for routine purposes were eligible to participate in this study. The inclusion criteria were adults between 18 and 50 who already had orders to undergo blood testing. We excluded patients with a history of motion sickness, pregnant women, a history of bloodborne diseases, use of pain medication on the day of the study, use of electronic medical devices (such as hearing aids, defibrillators, and pacemakers), and anyone who was currently experiencing a headache. Because the subjects were required to operate the IVR application using a handheld controller, we also excluded subjects with double upper extremity amputations and those who were legally blind.

Intervention and Data Collection

An associate investigator (AI) recruited potential participants consecutively as they approached the ticket kiosk to draw a number at the lab. Next, we invited patients interested in participating in the study to a nearby room to review the study information and complete the screening and consent forms. Volunteers meeting the inclusion criteria received a brief standardized instruction on the Oculus Go head-mounted device and were allowed sufficient time to become comfortable with its use. The investigator then instructed each participant to draw a pre-randomized envelope from a container. The envelopes, consisting of a demographic information sheet, data collection sheet, and the preprinted paper identifying the assigned cohort, were randomized using the Microsoft Excel random number generator.

Experimental group subjects underwent an IV blood draw with the VR headset mounted while playing the IVR game Ocean Rift. In this game, they could explore a virtual underwater safari park that included multiple environments to interact with, such as coral reefs, shipwrecks, lagoons, the Arctic, and prehistoric seas. They could also interact with several animal species of their choice, including dolphins, turtles, sharks, rays, whales, sea lions, manatees, and dinosaurs. Control group subjects underwent the same procedure with the headset mounted but with the IVR application turned off.

Participants then proceeded to the specimen room to undergo an IV blood draw. Immediately before the blood draw, the participants completed a questionnaire assessing their current anxiety levels and the pain they expected to experience. One unblinded AI assisted the participants with mounting and using the IVR device before and during the blood draw. The remaining investigators were blind to the list showing the assigned cohort. The phlebotomists then performed an IV blood draw for both groups in the nondominant arms, as we preferred the subjects to use their dominant hands to operate the Oculus Go controller. Those unable to provide specimens from the nondominant arm underwent blood draw in the dominant arm instead and worked the controller with their nondominant hand. After completing the procedure, the participants completed a post-procedure questionnaire assessing their self-reported “perceived” pain intensity utilizing a 0-100 mm VAS. We used Likert scales to measure the patients’ degree of satisfaction using the IVR while undergoing blood draw and to the likelihood that they would ask for IVR in future procedures. We defined the Likert scales as 1—being very
dissatisfied/unlikely, 2—dissatisfied/unlikely, 3—neither satisfied/likely nor dissatisfied/unlikely, 4—satisfied/likely, and 5—very satisfied/likely.

Data Analysis
We estimated our effect size and standard deviation based on studies by Todd et al. The minimal clinically significant pain difference (MCSD) was 13 mm, and the standard deviation was 17 mm on a 0-100 mm VAS. Assuming a two-sided $\alpha$ of 0.05 and $\beta$ of 0.20, we required a sample size of 27 subjects in each arm to detect the MCSD. We requested 60 participants to account for a possible dropout rate of 10%. We analyzed our data using SPSS software version 26. Due to its nonparametric nature, we reported the primary outcome (perceived pain) between the two groups as the median pain rating with the interquartile range (IQR) as measured on the VAS. In addition, we used the Mann–Whitney test to compare the pain scores between the two groups. A $P$-value of less than .05 is considered significant.

This study had several secondary outcomes. First, we measured the “expected level of pain with blood draw” immediately before and self-reported “pain intensity with blood draw” immediately after the procedure using the VAS. We also measured the level of anxiety the subject experienced. We reported these two outcomes as median with IQR and compared them using the Mann–Whitney U test. Finally, we used Likert scales to rate the following questions: (1) Overall, how satisfied were you with the use of VR during blood draw? (2) How likely would you be to request VR if it were available for use?. We reported these nonparametric ordinal variables using descriptive statistics.

RESULTS
Data collection occurred over 5 days. We approached 125 subjects to recruit for participation in the study. Sixty subjects met the inclusion criteria and were enrolled in the study. One subject left after consenting but before randomization. Twenty-eight subjects were randomized to the control group and 31 to the experimental group. One subject in the experimental group failed to complete the post-procedural questionnaire. Thus, 58 participants completed the study (Fig. 1). The mean age of the control group was 32.04, and the experimental group was 31.26. Table I depicts the subjects’ self-reported expected and perceived pain scores associated with blood draws. The median (IQR) “perceived” pain score for the control group was 6.50 (0.25-30.75), and the median (IQR) “perceived” pain score for the experimental group was 5.00 (1.00-24.25); an absolute difference of 1.5 mm. The difference between these groups reached neither clinical nor statistical significance, $P = .55$. The self-reported “perceived” median (IQR) anxiety scores were 12.5 (3.00-70.75) among the control group and 5.5 (1.00-27.25) among the experimental group, likewise not statistically significant, $P = .06$.

Tables II summarizes pre-procedure “expected” pain and post-procedure “perceived” pain. In both groups, the subjects expected to experience a higher level of pain with blood draw than they actually perceived, as demonstrated by the expected pain score and the self-reported perceived median pain score (control group 20 vs. 6.5, $P = .25$, and experimental group 22
Table II. Secondary Outcome: Expected vs. Perceived Self-reported Median Pain Scores Associated with Venipuncture

<table>
<thead>
<tr>
<th>Cohorts</th>
<th>Expected (interquartile range [IQR])</th>
<th>Perceived (IQR)</th>
<th>Difference</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control group, n = 28</td>
<td>20 (1.25-45.00)</td>
<td>6.5 (0.25-30.75)</td>
<td>13.5</td>
<td>.25</td>
</tr>
<tr>
<td>Experiment group, n = 31</td>
<td>22 (5.00-38.00)</td>
<td>5 (1.00-24.25)</td>
<td>17</td>
<td>.001</td>
</tr>
<tr>
<td>Difference control vs. experiment</td>
<td>2</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P-Value</td>
<td>0.40</td>
<td></td>
<td>0.55</td>
<td></td>
</tr>
</tbody>
</table>

Table III. Secondary Outcome: Satisfaction with Immersive Virtual Reality (IVR) Use and Preference for Use in Future Venipuncture

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>N</th>
<th>Min</th>
<th>Max</th>
<th>Median</th>
<th>Interquartile range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfaction with IVR use for pain</td>
<td>30</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Satisfaction with IVR use for anxiety</td>
<td>30</td>
<td>3</td>
<td>5</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>Will use in future venipuncture</td>
<td>30</td>
<td>2</td>
<td>5</td>
<td>5</td>
<td>1</td>
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</tbody>
</table>

vs. 5, \( P < .01 \). Table III presents median Likert scores assessing the degree of satisfaction with the use of IVR concerning pain and anxiety relief and the likelihood of requesting IVR use during future procedures if available in the experimental group. The median (IQR) Likert scores assessing satisfaction with IVR for pain and anxiety were both 5 (4.00-5.00) in both groups. No participant scored below 3 on the Likert scale for satisfaction with pain or anxiety. The median (IQR) Likert score assessing the likelihood of requesting IVR use during future procedures if available among the experimental group was also 5 (4.00-5.00).

**DISCUSSION**

Patients experience pain and anxiety when undergoing IV blood draws. McLenon and Taddio et al. reported that 20-30% of young adults experience fear of needles such that some avoid vaccination and health care throughout their adulthood.\(^{13,14}\) Minimizing pain and anxiety associated with venipuncture without adverse effects improves patients’ clinical experience.

Virtual reality (VR) devices are an effective non-pharmacologic technique for lowering the pain patients perceive when undergoing painful procedures. For example, Nilsson et al. reported a significant reduction in perceived pain and distress using VR devices during placement of subcutaneous venous port access in pediatric cancer patients receiving chemotherapy.\(^{10}\) Özalp Gerçeker et al. likewise reported reduced pain, fear, and anxiety in pediatric patients undergoing IV blood draws when using VR devices with the *Ocean Rift* application.\(^{8}\)

In the current study, we compared two cohorts of adult patients undergoing IV blood draws to determine if the reduction of perceived pain and anxiety seen in pediatric patients while using IVR extends to adult patients undergoing a similar procedure. Our primary outcome finding was different from the results in previously published studies. Our adult subjects who underwent blood draw using IVR (Oculus Go head-mounted device while playing *Ocean Rift*) reported a similar level of self-reported pain score when compared to the control group. The absolute difference of 1.5 mm did not achieve the MCSD defined as >13 mm.

In a study comparing reported pain levels of patients undergoing dressing changes, Guo et al. found that patients who used IVR saw a reduction of pain score from 6.52 (before dressing change) to 2.63 (after) vs. the control group (eyes closed) who reported a pain increase from 6.49 (before dressing change) to 7.64 (after).\(^{9}\) Likewise, Furman et al. reported that patients who use IVR during periodontal scaling and root planing procedures experienced less pain than patients who underwent the same procedure while watching a movie and among those who only wore goggles.\(^ {11}\) Our results may indicate that the benefit of IVR may not be realized in the adult population undergoing as brief of a procedure as an IV blood draw. Adult subjects appeared to anticipate higher pain levels than they experienced, with the expected median pain score at 22 mm vs. perceived pain score at 5 mm (experimental group) and 20 mm vs. 6.5 mm (control group).

Immersive virtual reality (IVR) as a distraction during the IV blood draw was safe to use, with none of the study participants experiencing adverse effects. Furthermore, the subjects in this study reported overwhelming satisfaction with IVR use during blood draws as a distraction for pain and anxiety and would use it in future procedures (if available). Regarding cost and preparation for use, the total cost for the VR headset with the game *Ocean Rift* was $200.00. Although pharmacologic options for pain control and anxiolysis (such as midazolam and EMLA cream) may cost under $2.00-4.00 per dose,\(^{15,16}\) a single VR headset may potentially be used hundreds of times. In addition, the AI took less than 2 minutes to prepare the device for use. Therefore, IVR may be a reasonable adjunct to pharmacologic therapies due to the safety profile, low device cost, and short preparation time.

**Limitations**

This study has several limitations. First, we conducted this study in a quiet lab atmosphere. Our participants were calm, without ongoing pain or distress that are often present in settings such as the ED, intensive care unit, or deployed environments. Second, phlebotomists performed IV blood draws.
draws in our study. Their experience in gaining IV access may be greater than that of nurses or other medical personnel; therefore, these results may not be generalizable to all adult patients receiving IVs. Third, the subjects in the control group underwent IV blood draws with the headset mounted but with the IVR application turned off to blind them; this action may not simulate the actual standard of care as patients undergoing IV blood draw typically do not do so with blindfolding. Lastly, failure to collect in-depth demographic data is another limitation. While the investigators assumed that the study subjects in both arms were similar due to the consecutive nature of recruiting, the authors cannot comment on any potential demographics associated with IVR use during painful procedures.

**CONCLUSION**

This study demonstrated that using IVR during blood draws did not significantly lower perceived pain in adult patients. The results showed that adult subjects in this study expected a higher level of expected pain and anxiety during the procedure than they ultimately perceived, with a significant difference between expected and perceived pain among the experimental group. Based on Likert scores, the subjects were almost unanimously satisfied with IVR use during blood draw.

**For Future Studies**

Future investigators may consider the use of more exhilarating applications in their studies. While the use of Ocean Rift is very mild in intensity, applications such as Rollercoaster may lead to more significant distraction. It may also be helpful to provide participants with multiple applications to choose from, as some patients may prefer shooting games or educational games.

**FUNDING**

None declared.

**CONFLICT OF INTEREST STATEMENT**

None declared.

**REFERENCES**


