BRIEF COMMUNICATION

Transfer validity testing of a virtual reality simulation for umbilical venous catheter placement

Harris Nisar[1,2,4], Nicole M. Rau[3,4]✉, Taylor Gohman[3], M. Jawad Javed[3] and Avinash Gupta[2]

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INTRODUCTION

Neonatal procedures such as umbilical venous catheter (UVC) placement are infrequently performed but highly emergent [1]. The infrequency of performing these procedures may lead to skill atrophy [2]. Recently, virtual reality (VR) has shown promising impact with surgical simulators demonstrating both efficacy and cost effectiveness [3]. Based on this impact, we developed a VR simulator for UVC placement and established its validity and usability [4]. However, an important question remained: do the skills trained in virtual environments transfer to real life? In this work, we compare the transfer of skills between traditional education modalities (video) and our VR simulator. We hypothesize that both modalities will lead to improved comfort to perform UVC placement and that VR participants will be able to correctly perform the steps of the procedure.

METHODS

Pediatric and medicine/pediatric residents were recruited for an unblinded randomized controlled trial comparing video to VR simulation. Residents were excluded if they transferred from another program or repeated a year of residency to prevent differences in exposure to UVC placement. The trial received approval from the Institutional Review Board and all participants provided informed consent after which randomization occurred.

The video group watched a prerecorded video of UVC placement, while the VR group utilized the VR simulator, which includes a tutorial related to operating the simulator and a walkthrough of the procedure (see supplementary information for additional description). Immediately after the educational intervention, both groups performed UVC placement on a manikin (Laerdal newborn anne manikin, Stavanger, Norway) and were scored using a rubric to capture performance (Supplementary Fig. 1). Both groups also completed pre/post questionnaires to obtain demographic information and assess comfort with UVC placement (Supplementary Fig. 2).

Wilcoxon rank-sum tests compared pre and post-tests, total time to complete the procedure, and percent correct between groups. $p < 0.05$ was considered statistically significant. All statistical analyses were performed using SAS software version 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

In total, 18 subjects (12 female, 6 male) were recruited with 10 randomized to the video group and 8 to the VR group. There were no significant demographic differences between the video and VR groups (Supplementary Table 1). Both groups were predominately female ($p = 0.32$), were pediatric residents ($p = 0.22$), and had no previous VR experience ($p = 1.00$). The median number of NICU rotations was 1.3 for the video group and 2.0 for the VR group ($p = 0.25$). Ninety percent of the video group reported performing zero UVCs independently compared to 87.5% of the VR group ($p = 1.00$).

We additionally measured the change in comfort to perform each step of the procedure pre and post educational intervention. For both the video and VR group, there was a statistically significant improvement in comfort after the educational intervention for each step of the procedure. However, the amount of improvement between the video and VR groups was not statistically significant ($p = 0.63$).

Table 1 shows the differences between groups in the total time to complete UVC placement on the manikin and the percent of correct steps on the rubric. The VR group completed UVC placement faster than the video group (146.6 s ± 35.9 vs. 225.3 s ± 80.9; $p = 0.03$). There was no difference in the percent correct between groups (90.1% ± 11.6 vs. 85.4% ± 9.6; $p = 0.26$).

DISCUSSION

Previous work has demonstrated that pediatric residents are leaving residency unprepared to perform neonatal procedures independently [5]. Attendance of fewer deliveries during training, increased numbers of advanced practice providers, and duty hour restrictions likely account for this [6]. The newly approved ACGME changes that decrease the number of required ICU months may make this trend worse. New, innovative teaching methods are needed to combat this problem.

This study demonstrates that the skills taught in our virtual reality simulation transfer into performance of the procedure on a manikin, although we acknowledge that performance of a procedure on a manikin is significantly simpler than performance on a real patient. Participants in the VR group scored as well as the traditional video group but did perform the procedure faster. Additionally, when asked to rate their comfort performing the individual steps of the procedure, residents' mean comfort scores pre intervention were 1.88–3.25 (range 1–5) representing uncomfortable to neutral. Residents reported feeling uncomfortable performing even relatively simple steps, with the lowest mean score achieved for placing the cord tie. After both educational interventions, mean scores improved to 4.1–4.9 (range 2–5) for each step. Given 89% of participants reported never performing UVC placement independently and 50% of participants reported never assisting with UVC placement, this lack of comfort is not surprising.

[1]Healthcare Engineering Systems Center, University of Illinois at Urbana-Champaign, 1206 W. Clark St., Urbana, IL 61801, USA. [2]Department of Industrial and Enterprise Systems Engineering, University of Illinois at Urbana-Champaign, Street, 104 S. Matthews Ave., IL 61801, USA. [3]Department of Pediatrics, Division of Neonatology, University of Illinois College of Medicine at Peoria, 530 NE Glen Oak Ave., Peoria, IL 61637, USA. [4]These authors contributed equally: Harris Nisar, Nicole M. Rau. ✉email: nrau@uic.edu

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Table 1. UVC placement total time and percent score by group.

Variables	Group			*P* value
	Total ***N*** **= 18(%)**	**Video** ***N*** **= 10(%)**	**VR** ***N*** **= 8(%)**	
Total time				0.029 [W] [+]
N	14	8	6	
Median (min–max)	173.0 (116.0–395.0)	196.2 (147.0–395.0)	138.7 (116.0–214.0)	
Mean ± SD	191.6 ± 75.2	225.3 ± 80.9	146.6 ± 35.9	
Median (q25–q75)	173.0 (147.0–214.0)	196.2 (173.0–261.0)	138.7 (121.3–150.9)	
Missing	4	2	2	
Percent score				0.259 [W] [+]
N	18	10	8	
Median (min–max)	91 (64–100)	91 (64–100)	86.5 (73–100)	
Mean ± SD	88 ± 10.69	90.1 ± 11.58	85.375 ± 9.55	
Median (q25–q75)	91 (82–100)	91 (82–100)	86.5 (77.5–91)	
Missing	0	0	0	

[+]Exact test.
[W]Wilcoxon rank-sum test.

After using our VR simulation, resident comfort improved across all steps of the procedure. Such an on-demand solution could provide an opportunity for residents to frequently and independently practice this procedure for which they are lacking real world experience.

Our study has several limitations. First, our small sample size did not allow us to detect differences in comfort or performance between groups. This was a pilot study which enrolled 18 residents however a power analysis based on these results demonstrated that 54 participants are needed to detect a difference in performance. Secondly, our participants performed the manikin assessment immediately after the educational interventions. This choice was made for procedure day logistics but may limit differentiation between educational methods. A larger, longitudinal study is currently underway to determine if this technology is more effective than traditional teaching methods and how these skills are maintained over time.

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AUTHOR CONTRIBUTIONS

HN developed the virtual reality simulation, drafted the initial manuscript, and critically reviewed and revised the manuscript. NMR assisted in content development for the virtual reality simulation, conceptualized and designed the study, designed the data collection instruments, collected data, carried out initial analyses, drafted the initial manuscript, and critically reviewed and revised the manuscript. TG assisted in content development for the virtual reality simulation, designed the data collection instruments, collected data, carried out the initial analyses, and critically reviewed and revised the manuscript. MJJ assisted in content development for the virtual reality simulation, conceptualized and designed the study, carried out the initial data analyses, and critically reviewed and revised the manuscript. AG developed the virtual reality simulation and critically reviewed and revised the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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COMPETING INTERESTS

The authors declare no competing interests.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by University of Illinois College of Medicine at Peoria IRB 1 (IRB # 00000688) and all participants provided written informed consent. The study was performed in accordance with the Declaration of Helsinki.

ADDITIONAL INFORMATION

Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41372-025-02246-9.

Correspondence and requests for materials should be addressed to Nicole M. Rau.

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