Subclavian Central Venous Access Mixed Reality Simulator: Preliminary Experience

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Introduction

- Part-task simulation trainers offer a promising alternative to bedside teaching to learn subclavian central venous (SC-CV) access through deliberate practice for the acquisition of clinical skills and improved patient care. The objective of this study was to determine the effectiveness as a learning tool of a novel Central Venous Access Mixed Reality Simulator, which can be viewed at http://simulation.health.ufl.edu/research/cvl_intro.wmv. A mixed reality simulator combines both physical and virtual components, with the virtual components registered in 3D space at the same location, orientation and size as the physical implementation would have occupied. In the simulator, the tip of an actual needle attached to a syringe is tracked by a magnetic sensor relative to the physical and virtual components of the simulator and allows the procedure and needle tip trajectory to be visualized for guidance and/or after action review (debriefing). Compared to existing central venous access trainers, this new simulator will detect iatrogenic pneumothorax.

Figure 1: The subclavian central venous access mixed reality simulator records and analyzes the placement of the needle

Materials & Methods

Anesthesiology residents and attending physicians were selected to perform three runs on the simulator. Levels of training included trainees ranging from residents in PGY1 to PGY4, fellows, and faculty. Participants completed:

1) a pre-intervention questionnaire about previous subclavian central venous line placement
2) simulation run #1 (without the use of the visualization software) established the participant's baseline knowledge and skills
3) a teaching intervention by the same instructor followed by simulation run #2 – with the use of the simulator's mixed reality (MR) visualization software
4) simulation run #3 – a final test using the simulator without the visualization software.
5) A post-intervention questionnaire about the realism of the simulator

The main test parameters were time to complete SC-CV access and CVLScore, a composite score of efficiency and safety scores automatically generated by the simulator's scoring algorithm.

Results

From run #1 to run #3, average CVLScore was reduced by 23 points in all participants (N=28) and a reduction in average time (62.4 sec) to obtain SC-CV access was observed. We performed repeated measure ANOVA on the outcomes from the three waves of data collection with follow-up pairwise dependent sample t-tests. There were reductions in average time ($F=14.28$, $p<.0001$), the number of attempts ($F=10.77$, $p=.0001$), skin punctures ($F=6.59$, $p=.004$) and SCCVL score ($F=14.59$, $p<.0001$) (Table 1). For all outcomes, there were significant differences between Run 1 and Run 2 and between Run 1 and Run 3, but not between Run 2 and Run 3 ($p<.05$). The increased success rate from 82.1 (Run 1) to 92.9% (Run 3) was not significant ($p=.08$). Complication rates for pneumothoraces and subclavian arterial punctures were reduced from 11% to 7% and 13% to 7%, respectively (Table 2). On a five point scale (1=strongly disagree to 5=strongly agree), on average participants agreed that the SC-CV access simulator was realistic (M=4.1) and strongly agreed that the simulator should be used as a training/educational tool (M=4.8).

Results

		Run 1			Run 2			Run 3		
Variable	N	Mean (SD)	Min	Max	Mean (SD)	Min	Max	Mean (SD)	Min	Max
Time (seconds)	28	107.64 (101.92)	13.00	378.00	36.79 (41.65)	7.00	184.00	35.71 (46.09)	6.00	198.00
Number of Attempts	28	8.46 (7.12)	1.00	22.00	3.32 (3.31)	1.00	11.00	4.29 (5.21)	1.00	20.00
Number of Skin Punctures	28	3.61 (2.96)	1.00	14.00	2.14 (1.63)	1.00	6.00	1.89 (1.62)	1.00	7.00
SC CVL Score	28	46.99 (36.71)	1.30	100.00	16.91 (18.91)	0.70	67.60	19.31 (28.00)	0.60	100.00
Success (%)	28	82.14 (39.00)						92.86 (26.23)		

Table 1: Outcomes analysis of three runs [SC CVL Score (range: best score 0 – worst score 100)]

Time to Obtain SC-CVL Access Reduction (s)	62.4
CVLScore Reduction	23
Attempt Reduction (Run 3- Run 1)	3.6
PTX (Run 1)	11.1%
PTX (Run 3)	6.6%
PTX Reduction	4.5%
SC-arterial puncture (Run 1)	13.3%
SC-arterial puncture (Run 3)	6.6%
SC-arterial puncture Reduction	6.7%
Successful SC vein access (Run1)	83.3%
Succesful SC vein access (Run3)	90.0%
Improved Successful SC vein access (R3-R1)	6.7%
Increase in Confidence Scores	2.8
Overall Realistic Representation	4.07
Correct Anatomical	4.5
Tactile feedback of needle	4
Steering of the needle	4.27
Experience on simulator useful in clinical practice	4.83
Simulator used as a training/education tool	4.8
Simulator improved my technical proficiency	4.27
Satisfaction with entire training program	4.67
Experience with simulator will help in future SC-CVC	97%

Table 2: Summary of SC-CV access data and questionnaires

Conclusions

Our preliminary data indicate that the UF Mixed Reality Simulator offers a realistic representation of SC-CV access. Although there is a trend toward better performance with experience, the effect of PGY-level on performance variables was not statistically significant. This is however preliminary data and we planned a priori increasing the sample size at each level of training. This new device could be implemented into residency training programs in multiple disciplines to help training in subclavian venous access. This simulation training translates clinically to a likely reduction in pneumothoraces and arterial punctures.

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Funding

UF College of Medicine Department of Anesthesiology Jerome H Modell Endowed Professorship

UF College of Medicine Chapman Education Center (COMCEC) Educational Research Grant