Summer 8-25-2019

Improving Knowledge and Self-Efficacy in Student Registered Nurse Anesthetists through Simulation Based Learning on Pulmonary Artery Catheter Insertions

Neal Allen Johnson
DePaul University, nealjohnson88@gmail.com

Amanda Lipa
DePaul University, amandalipa@gmail.com

Improving Knowledge and Self-Efficacy in Student Registered Nurse Anesthetists through Simulation Based Learning on Pulmonary Artery Catheter Insertions

A Doctor of Nursing Practice Project Defense

Presented in

Partial Fulfillment of the

Requirement for the Degree of

Doctor of Nursing Practice

By

Neal Johnson, BSN, RN and Amanda Lipa, BSN, RN

May 31, 2019

School of Nursing

College of Science and Health

DePaul University

Chicago, Illinois

NorthShore University HealthSystem

School of Nursing Anesthesia

Evanston, IL

Author Information

Amanda Lipa SRNA, BSN, DNP-C is currently enrolled as a third year student at NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University

Neal Johnson SRNA, BSN, DNP-C is currently enrolled as a third year student at NorthShore University HealthSystem School of Nurse Anesthesia and DePaul University

The DNP Project Committee

Pamela Schwartz, DNP, CRNA, Chairperson

Julia Feczko, DNP, CRNA, Member

Keywords: Student Registered Nurse Anesthetists (SRNA), Pulmonary Artery (PA) catheter, video based learning, low-fidelity simulation

Abstract: Simulation is increasingly being used within the educational setting for invasive procedures, such as pulmonary artery (PA) catheter insertion. The purpose of this study was to assess how student registered nurse anesthetists (SRNAs) knowledge and confidence is effected by viewing an educational video and participating in a low-fidelity simulation. Dual coding theory was used to develop a single group pre-test and post-test study. A convenience sample of second year SRNAs was used. Participants completed a knowledge assessment tool and a confidence survey. Each participant then viewed the video and completed a hands on low-fidelity simulation. Following both these, each participant completed another knowledge assessment tool and confidence survey. SPSS was used to analysis the data. On the pre-study questionnaire 95.5% were not confident in their ability to place a PA catheter and on the post-study questionnaire this decreased to 18.2%. The mean score of the knowledge assessment tool improved from 7.73 (SD = 3.01) to 10.77 (SD = 3.29) (P = 0.001) following viewing the video and performing the low-fidelity simulation. Results of this study indicate benefits for nurse anesthesia trainee to the use video and low-fidelity simulation for teaching PA catheter insertion.

Introduction

Throughout the healthcare community there has been an increased use of simulation for training and education. Simulation has been shown to improve a provider's ability to complete a skills checklist on the first attempt lending it especially useful for teaching invasive procedures.[1] Acknowledging the benefits of simulation influenced the Institute of Medicine's most recent initiative to maximize the use of simulation.[2] The Institute of Medicine describes the benefits of simulation as a way to ensure competency, to increase workforce numbers, and to strengthen team training.[2]

One way to optimize a simulation experience is by coupling it with an educational video. The benefits of this educational technique can be explained by dual coding theory, which was first conceptualized by Allan Pavio in 1971.[3] It explains that the human brain stores processed information along two short-term channels; verbal and nonverbal.[3] As a person watches an educational video or performs a simulation, they process information through both channels. What is heard on the video or during the simulation is stored in the verbal channel of the learner's brain. Separately, what the learner sees on the video or performs during the simulation, is stored in the nonverbal channel of their brain. In order to retain information being processed, connections are made between the verbal and nonverbal channels to form an interconnected relationship between the two channels in the mind.[3] Utilizing video and simulation for teaching technical skills, forces the learner to use both the verbal and nonverbal channels.

Current nurse anesthesia education relies on the quality and duration of clinical experiences, with the goal of attaining exposure to a wide variety of situations, interventions, and procedures.[4] Simulation can enhance the clinical experience of Student Registered Nurse Anesthetists (SRNA). Performing invasive procedures always demands safety for any healthcare

provider, regardless of the type and level of training.[4] Insertion of a pulmonary artery (PA) catheter is an invasive procedure that carries the risk of serious complications such as trauma to vessels, trauma to the heart (including the valves), and arrhythmias.[5] Thus, it is important for the provider to understand the steps for inserting the PA catheter. In addition, correct waveform interpretation is important to ensure accurate pressure measurements that may be used to guide patient treatment.[6]

Doctor Swan, the inventor of the PA catheter, stated that practitioners should place a minimum of 50 catheters every year to maintain competency.[7] With the development and increased use of less invasive hemodynamic monitoring, the frequency of PA catheter use has diminished drastically since first being introduced in the 1970s.[3] This has led to a wide competency range among current providers and providers in training, causing a patient safety concerns.[3] For example, in the critical care setting, program directors often feel there isn't an adequate amount of real life training available for fellows in their programs.[8] Those who used simulation felt it was an adequate supplement to the limited number of real-life experiences available.[8]

While there is no current research discussing the use of simulation for PA catheter insertion, simulation is currently being utilized for teaching an invasive procedure that is necessary for PA catheter usage. Prior to inserting a PA catheter, a central venous catheter must be inserted. Simulation is being used to train practitioners in multiple medical and surgical departments throughout the hospital[9]. Not only are the participant's post-test knowledge scores increasing but their confidence and comfort with the procedure are increasing as well.[9] High-

fidelity training can be expensive and can be a limiting factor in its use for training.[10] For central line insertion, there is no significant difference in comfort, confidence, or performance of a trainee who experiences low fidelity simulation versus a trainee who experiences high fidelity simulation.[11,12] Low-fidelity simulation is less expensive and utilizes less equipment, which makes it the optimal educational tool for teaching PA catheter insertion techniques.

After the PA catheter is inserted the practitioner must be able to manage, interpret, and make treatment decisions based upon the information gathered from the waveforms and values.[13] Simulation has been used to teach and improve the confidence of new graduate critical care nurse practitioners in these skills.[13] This indicates an opportunity to use simulation to fill an educational gap for all practitioners who must identify and interpret waveforms as part of the insertion process.

The goal of this study was to develop an educational PA catheter insertion video and a hands-on low-fidelity simulation to address the following research questions:

1. How does viewing of a PA catheter educational video and participation in a low-fidelity simulation affect SRNA's knowledge of PA catheter insertion?
2. How does viewing of a PA catheter educational video and participation in a low-fidelity simulation affect SRNA's confidence in inserting a PA catheter?
3. In SRNAs, does perceived knowledge of PA catheter insertion correlate with actual knowledge?
4. Do SRNAs believe one teaching method (educational video or low-fidelity simulation) is superior to the other as it pertains to their knowledge and confidence in PA catheter insertion?

Materials and Methods

Study Design and Sample

A single group pre-test and post-test was used to evaluate changes in SRNA's knowledge and confidence after viewing an educational video and performing a low-fidelity simulation about PA catheter insertion. A script was developed for the educational video using content derived from Mittnacht et al. and Weinhouse.[5,14] Video content was reviewed for content validity by a panel of five experts until a perfect score was reached in the categories of clarity, relevance, simplicity, and consistency. The content in the low-fidelity simulation was taken directly from the validated content of the video.

A convenience sample of second year SRNAs were used as the participants of this study. Inclusion criteria for this study were any NorthShore University HealthSystem School of Nurse Anesthesia (NUHSNA) SRNAs enrolled in their second year of study at the time the study took place. All eligible SRNAs were registered nurses with either a bachelor's or master's degree, and had at minimum, two years of critical care experience. It was felt that all SRNAs would benefit from viewing the video and participating in the simulation so there was no control group. In order to avoid bias, implementation took place before second year SRNAs had their curriculum lecture on hemodynamic monitoring where similar information would have been presented. There were 24 eligible second year SRNAs and 22 that chose to participate. No written consent was obtained as all participants were informed that by completing and submitting the pre-test and post-test, consent was implied.

The study took place at NorthShore University HealthSystem Evanston Hospital in a meeting room that is utilized by the school for lectures. The video was viewed by all participants

as a group, followed by each participant taking part in the low-fidelity simulation in the hallway outside the meeting room. Participation in this study was completely voluntary. IRB approval was obtained from both NorthShore University HealthSystem and DePaul University.

Instruments

Four surveys were utilized. The first was a demographics survey, which included generic information regarding age, sex, and race as well as specific information regarding years of critical care experience as well as previous experience with PA catheter insertion. A pre-study questionnaire was developed to measure participants' perceived knowledge and confidence of PA catheter insertion prior to viewing the educational video and participating in the low-fidelity simulation. A 4-point Likert scale ranging from strongly disagree to strongly agree was used. Participants were asked to rate perceived knowledge of indications, contraindications, complications, and steps for PA catheter insertion as well as confidence in proper insertion.

The PA catheter insertion knowledge assessment tool (KAT) was developed with information derived from Mittnacht et al. and Weinhouse.[5,14] The KAT consisted of 14 questions total. The first three questions assessed the participants' knowledge of indications, contraindications, and complications of PA catheter insertion. The next three questions assessed the participants' knowledge of waveform interpretation based upon catheter tip location. The final eight questions asked participants to place the steps for insertion in the correct order.

The post-study questionnaire was a 4-point Likert scale ranging from strongly disagree to strongly agree. It was identical to the pre-study questionnaire with the addition of two questions. The first asked if the participant believed the video improved knowledge of PA catheter insertion more than the low-fidelity simulation. The second asked if the participant believed performing

the low-fidelity simulation improved confidence to insert a PA catheter more than watching the video.

Data Collection Procedure

An envelope labeled "demographics" containing the demographic survey was distributed to each participant and the group was given five minutes to complete individually. The demographic surveys were collected in the envelopes they were distributed in and kept separately from the rest of the tools. Each participant then received two envelopes with the same number on them, one labeled "pre-test" and the second labeled "post-test." Participants were asked to open the envelope labeled "pre-test" and complete both the pre-study questionnaire and the KAT. When completed, the pre-study questionnaire and KAT were collected in the envelope they were distributed in. Once all envelopes were collected the group of participants watched the educational video describing the indications, contraindications, complications, and steps for PA catheter insertion lasting about 10 minutes.

After the video was complete, participants individually took part in the low-fidelity simulation with one of the authors. The low-fidelity simulation consisted of a mannequin head with a central line already in place as shown in **Figure 1.** Blue towels were placed over the central line to create a pocket for the PA catheter to be inserted as shown in **Figure 2**. The low-fidelity simulation took each participant less than five minutes to complete. The low-fidelity consisted of a mannequin head with a central line already in place. While inserting the PA catheter a PowerPoint presentation was used to show waveforms seen during placement. During the simulation the author only provided guidance by stating information previously presented in the video, as well as change the waveforms on PowerPoint screen at the appropriate centimeter markings on the catheter. Once the participant had completed the low-fidelity simulation, they

were asked to return to the class room and open the envelope labeled "post-test" which contained the post-study questionnaire and KAT. The participants were able to complete both surveys at their own pace. The post-test was collected in the same envelope it was distributed in. At this point the participants were done with the study.

Analytic Procedure

Statistical Package for Social Sciences (SPSS) software was used to analyze pre and post study scores. Cronbach's Alpha was utilized to assess the reliability of the post study questionnaire. The Mann-Whitney U Test was used to compare the demographic categories of age, gender, type of critical care experience, and number of PA catheters inserted to the participants perceived and actual pre and post study scores. Because the data was not normally distributed, Wilcoxon Signed Rank Test was used to compare the pre and post KAT scores as well as the perceived knowledge and confidence from the pre and post study questionnaires. Spearman rank-order correlation was used to compare data from the pre-study questionnaire and KAT to demonstrate if a participants' perceived knowledge translated into a higher score on the KAT. Finally, data from the post-study questionnaire was evaluated to determine if SRNAs believed one teaching method was more useful than the other in relation to their knowledge and confidence of PA catheter insertion.

Results

A total of 22 second year SRNAs participated in the study. The participants' demographic data included gender, age, race, years of critical care experience, type of critical care experience, and number of PA catheter insertions. One participant chose not to fill out the demographic survey. As shown in **Table 1**, 8 (36.4 %) of participants were male and 13 (59.1 %) were female. Nearly all the participants were under the age of 40 (90.9 %: 20 out of 22) with the

majority being 20-29 (50 %). 72.7 %(16) listed their race as white while 13.6 %(3) and 9.1 %(2) listed their race as Asian/Pacific Islander and mixed race respectively. Most participants, 72.7 %(16), had 3-4 years of critical care experience before starting anesthesia school. Only 31.8 %(7) of participants had cardiac critical care experience. The majority of participants 54.5 %(12) had assisted in the insertion of 1-2 PA catheters prior to anesthesia school.

The pre and post study questionnaire assessed perceived knowledge and confidence of inserting a PA catheter. The post-study questionnaire on perceived knowledge had a Cronbach's alpha of 0.976. The majority of SRNAs (95.5%) felt they knew the indications for PA catheter placement while only 27.3% of SRNAs felt they knew the correct steps for PA catheter insertion on the pre-study questionnaire. The mean score of perceived knowledge were 2.68 (*SD* = 0.51*)* on the pre-study questionnaire and 3.43 (*SD* = 0.49) on the post-study questionnaire (Figure 1). Very few of the SRNAs (4.5%) were confident in their ability to insert a PA catheter on the pre-study questionnaire. On the post-study questionnaire, 81.8% of SRNAs felt confident in placing a PA catheter. Confidence mean scores increased from 1.36 (SD = 0.58) to 3.09 (SD – 0.68)**(Figure 3).**

Hypothesis testing using Related-Samples Wilcoxon Signed Rank Test rejects the null hypothesis that the median of differences between the mean pre and post study questionnaire scores equals 0 (*P* = 0.000) for both perceived knowledge and confidence **(Table 2**). Paired samples *t test* for pre and post perceived knowledge and confidence were statistically significant with the following values: *t*=-8.33*; P* = 0.000 *and t*=-11.53*; P* = 0.000, respectively.

The 14 question KAT assessed actual knowledge of PA catheter insertion. Scores on the pre-study KAT ranged from 3-13 and 5-14 on the post-study KAT. While no SRNA achieved a perfect score on the pre-study KAT, 6 SRNAs achieved a perfect score on the post-study KAT.

The mean score on the KAT increased from 7.73 (*SD* = 3.01) to 10.77 (*SD* = 3.29)(**Figure 3).** Hypothesis testing using Related-Samples Wilcoxon Signed Rank Test rejects the null hypothesis that the median of differences between the mean pre and post study KAT scores equals 0 (*P* = 0.001)**(Table 2).** Paired samples t test of pre and post actual knowledge was *t=-4.50; P* = 0.000.

The relationship between perceived knowledge and actual knowledge was determined using Spearman's rank order correlation. Pre and post study perceived and actual knowledge were statistically significant with the following values: $r_s = 0.463$; $P = 0.03$ and $r_s = 0.612$; $P = 0.002$, respectively.

The post-study questionnaire included two statements relating to the participants' feelings on video simulation and hands-on simulation. The first was "Watching the educational video improved my knowledge of pulmonary artery catheter insertion more than participating in the low-fidelity simulation." Answers ranged from 1 (Strongly Disagree) to 4 (Strongly Agree) and the mean score was 3.09 (*SD* = 0.97). The second statement was "Participating in the low-fidelity simulation improved my confidence in inserting a pulmonary artery catheter more than watching the educational video." All the participants agreed with this statement with a mean score of 3.59 (*SD* = 0.5).

The demographical categories of age, gender, type of critical care experience, and number of PA catheters inserted were tested for contributing factors on pre and post knowledge scores. Using the Mann-Whitney U Test, there was no statistically significant effect of these demographical categories on perceived or actual knowledge regarding inserting a PA catheter.

Discussion

Despite the decrease in use of PA catheters, it remains important that SRNAs have the knowledge and confidence to safely insert a PA catheter. In this study, a video and a low fidelity simulation were developed to assist in the teaching of this low-frequency but high-risk procedure. The data gathered was adequate to answer the proposed research questions. The video and low-fidelity simulation were effective in increasing the mean perceived knowledge scores from 2.68 to 3.43 as well as the mean actual knowledge scores from 7.73 to 10.77. This data demonstrates that the video and low-fidelity simulation that was developed was an effective tool for increasing SRNA knowledge of PA catheter insertion. The video and low-fidelity simulation were also effective for increasing confidence in PA catheter insertion as evidenced by mean confidence scores increasing from 1.36 to 3.09 (**Figure 3).**

In addition, there was a significant positive correlation between SRNAs' perceived knowledge and actual knowledge. SRNAs who thought they had more knowledge about the indications, contraindications, steps, and complications of PA catheter insertion scored better on the KAT. This increase of both types of knowledge shows that utilizing both a video and low-fidelity simulation is an effective way to incorporate Pavio's duel coding theory into teaching invasive procedures. In addition, a student provider who has an increased level of both perceived and actual knowledge will be able to provide safer patient care.

All of the SRNAs agreed that the hands-on simulation increased their confidence more than watching the video. This is consistent with what has been seen outside of healthcare for decades and is currently gaining momentum and is a focus of research within the healthcare community. Performing the low-fidelity simulation offers the provider an opportunity to obtain experience in which the stress of causing harm is eliminated. This allows the provider to focus on learning the skill which leads to an increased level of confidence. In addition, low-fidelity simulation is often

more engaging than watching the video which may contribute to the SRNA having increased confidence.

Nonparametric testing of the demographical categories of age, gender, type of ICU experience, and number of PA catheters inserted revealed no significant effect on perceived or actual knowledge of PA catheter insertion. This result was surprising because one would anticipate that a nurse with cardiac ICU experience would have more exposure to PA catheter insertion and would feel more confident at baseline. The absence of this indicates the importance of incorporating various learning techniques for all SRNAs so there will be increased confidence performing more invasive procedures in the clinical setting.

This study was limited by several factors. The population size consisted of a small convenience sample of second year SRNAs and the data was not evenly distributed, which limits generalizability of results. In addition, the nature of a pre and post-test design allows participants to have knowledge of the post test before taking it and could skew results due to recall bias.

The results of this study could be strengthened through further research. Retention of the knowledge SRNAs gained through watching an educational video and participating in a low-fidelity simulation could be tested by having the SRNAs complete another KAT several weeks or months after the original study. Including first and third year SRNAs in the study could increase the sample size and allow for more evenly distributed data.

Conclusion

Simulation is widely used as an adjunct teaching method in a variety of settings. In order to promote competence and patient safety, there is currently a push to increase the use of simulation in health care training. The decline of PA catheter use due to the development of

other noninvasive techniques has caused a decrease in teaching opportunities for actual placement. The findings of this study suggest watching an educational video and participating in a hands-on simulation can significantly increase both knowledge and confidence of those learning the skill of PA catheter insertion. Due to the positive results demonstrated in this study, the methodology used could be applied for teaching other anesthesia procedures.

Figure 1. Central line inserted through artificial skin and secured to a mannequin neck.

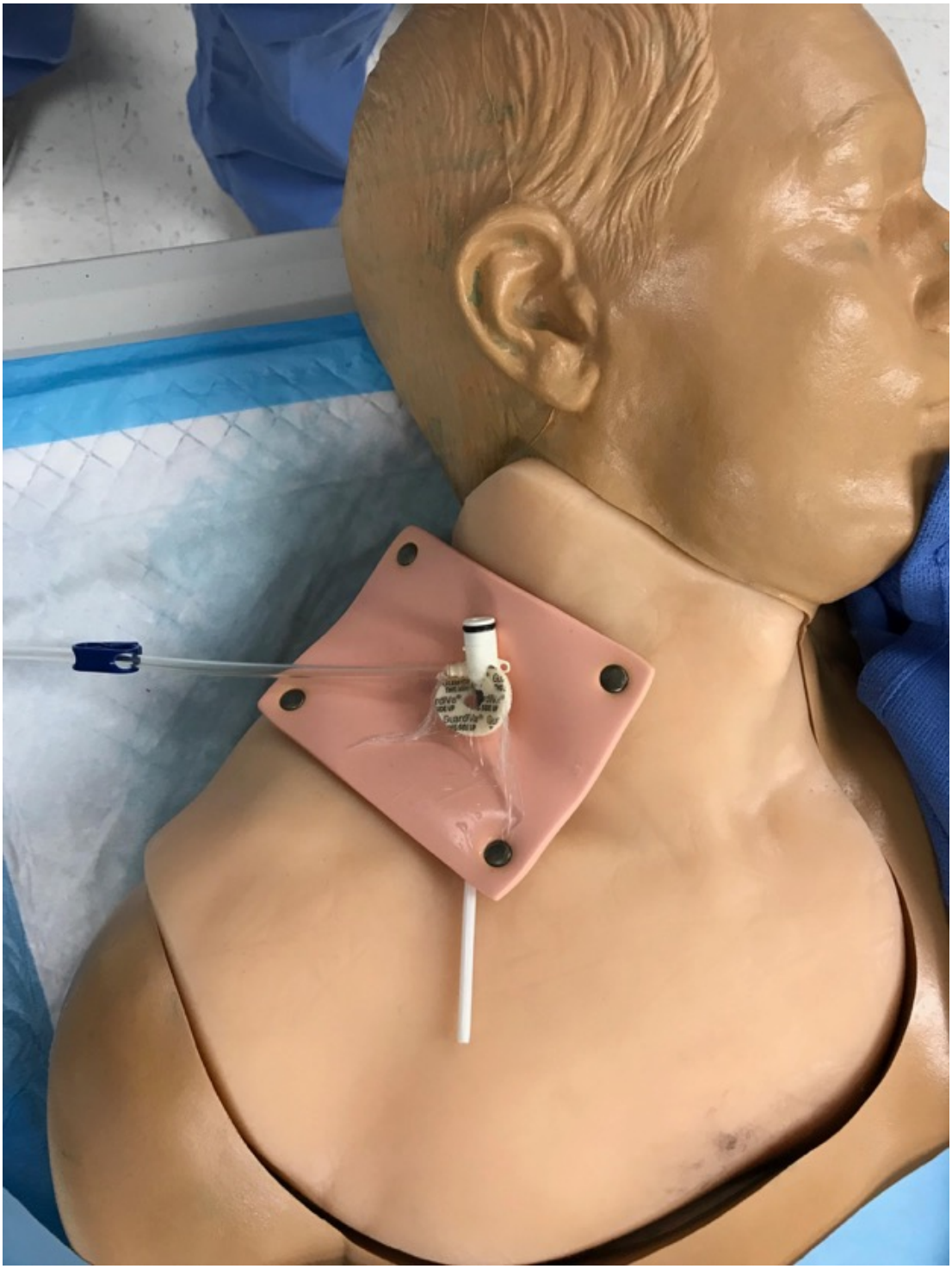

Figure 2. Blue towels covering and hiding the artificial skin to give the illusion that central line is actually inserted. Pulmonary artery catheter then coils underneath the blue towels during the simulation.

Table 1. Demographic Data

		Frequency	Percent	Vaild Percent	Cumulative Percent
Gender					
	Male	8	36.4	38.1	38.1
	Female	13	59.1	61.9	100.0
Age Group					
	20-29	11	50.0	52.4	52.4
	30-39	9	40.9	42.9	95.2
	40-49	1	4.5	4.8	100.0
Race					
	White	16	72.7	76.2	76.2
	Asian/Pacific Islander	3	13.6	14.3	90.5
	Mixed Race	2	9.1	9.5	100.0
Years of Critical Care Experience					
	1-2	1	4.5	4.8	4.8
	3-4	16	72.7	76.2	81.0
	5-6	2	9.1	9.5	90.5
	>6	2	9.1	9.5	100.0
Type of ICU					
	Cardiac	7	31.8	33.3	33.3
	Other (Neuro, Medical, Surgical, Pediatric)	14	63.6	66.7	100.0
Number of PA Catheters					
	1-2	12	54.5	60.0	60.0
	>3	8	36.4	40.0	100.0

Abbreviations: ICU, intensive care unit; PA, pulmonary artery.

Figure 3. Pre and post mean scores of perceived knowledge, confidence, and actual knowledge.

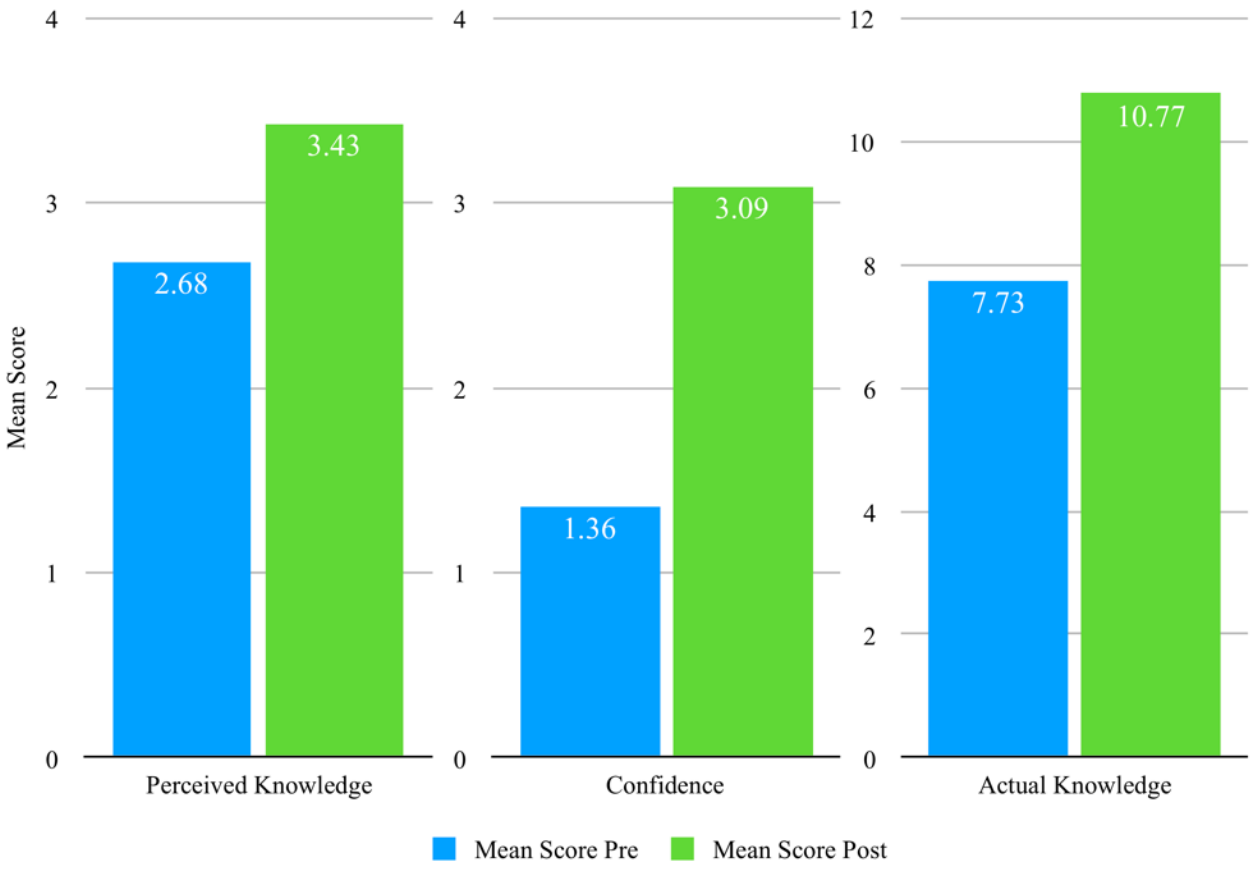

Table 2. Knowledge Assessment Tool and Confidence Survey Analysis

	Pre-Study Confidence	Post-Study Confidence	Pre-Study KAT Score	Post-Study KAT Score
N	22	22	22	22
Mean	1.36	3.09	7.73	10.77
Std. Deviation	0.581	0.684	3.01	3.29
Minimum	1	2	3	5
Maximum	3	4	13	14
Related-Samples Wilcoxon Signed Rank Test	The median of differences between Pre-Study Confidence and Post-Study Confidence equals 0		The median of differences between Pre-Study KAT Score and Post-Study KAT Score equals 0	
	Sig. = 0.000 Reject the null hypothesis		Sig. = 0.001 Reject the null hypothesis	

References

1. Alsaad AA, Bhide VY, Moss Jr JL, Silvers SM, Johnson MM, Maniaci MJ. Central line proficiency test outcomes after simulation training versus traditional training to competence. *Ann Am Thorac Soc*. 2017;14(4):550-554. doi: 10.1513/AnnalsATS.201612-987OC
2. Cannon-Diehl MR, Rugari SM, Jones TS. High-fidelity simulation for continuing education in nurse anesthesia. *AANA J*. 2012;80(3):191-196.
3. Clark JM, Paivio A. Dual coding theory and education. *Educ Psychol Rev*. 1991;3(3):149-210.
4. Bhagwat M. Simulation and anaesthesia. *Indian J Anaesth*. 2012;56(1):14.
5. Weinhouse G. Pulmonary artery catheterization: Indications, contraindications, and complications in adults. In: Post T, ed. *UpToDate.* Waltham, MA: UpToDate; 2017. www.uptodate.com. Accessed April 2018
6. Bridges E. AACN practice alert: pulmonary artery/central venous pressure monitoring in adults. *Crit Care Nurse,* 2016;36(4):e12-e18. doi: 10.4037/ccn2016268
7. Swan HJ. What role today for hemodynamic monitoring? When is this procedure indicated? How much training is required?. *J Crit Illn*. 1993;8(9):1043-1050.
8. Tukey MH, Wiener RS. The current state of fellowship training in pulmonary artery catheter placement and data interpretation: a national survey of pulmonary and critical care fellowship program directors. *J Crit Care*. 2013;28(5):857-861. doi: 10.1016/j.jctc.2013.06.003
9. Grudziak J, Herndon B, Dancel RD, Arora H, Tignanelli CJ, Phillips MR, Crowner JR, True NA, Kiser AC, Brown RF, Goodell HP. Standardized, interdepartmental, simulation-based central line insertion course closes an educational gap and improves intern comfort with the procedure. *Am Surg*. 2017;83(6):536-540.
10. Muckler VC, Kampo S, Morgan B. Creation of a low-cost simulated trachea for deliberate practice of cricothyrotomy and retrograde wire use. *AANA J*. 2017;85(4):271-275.

11. Diederich E, Mahnken JD, Rigler SK, Williamson TL, Tarver S, Sharpe MR. The effect of model fidelity on learning outcomes of a simulation-based education program for central venous catheter insertion. *Simul Healthc*. 2015;10(6):360-367. doi: 10:360-367
12. Friedman Z, Siddiqui N, Katznelson R, Devito I, Bould MD, Naik V. Clinical impact of epidural anesthesia simulation on short-and long-term learning curve: high-versus low-fidelity model training. *Reg Anesth Pain Med*. 2009;34(3):229-232. doi: 10.1097/AAP.0b013e3181a34345
13. Ngu PC, Lin HL, Lin HC. Learning effectiveness of nurses caring for patients with pulmonary artery catheters using e-learning and simulation approaches. *J Nurs Educ Pract,* 2016;6(8):74-83. doi: 10.5430/jnep.v6n8p74
14. Mittnacht A, Reich D, Sander M, et al. Monitoring of the heart and vascular system. In: Kaplan JA, Cronin B, Maus T, eds. *Kaplan's Essentials of Cardiac Anesthesia for Cardiac Surgery.* 2nd ed. Philadelphia, PA: Elsevier; 2018:203-225.