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Improving Proficiency in Central Venous Catheter Insertion: Standardized Simulation Based Training for Internal Medicine House Staff

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Background

Central venous catheter (CVC) placement is often a necessary procedure in critically ill patients. In the U.S. alone over 5 million CVCs are placed annually. Frequently, there is no standardized training program for house staff and CVC placement training is done “on the job” under the guidance of another resident deemed to be competent to perform the procedure. Even in programs where simulation training is utilized, there is a lack of standardization of this training. This lack of systematic training can lead to significant variation in procedural technique and ability to place CVCs. Complications have been reported in 15-20% of patients, which leads to significant increases in hospital cost, morbidity and even mortality [1,2]. The American Board of Internal Medicine strongly recommends utilization of simulation training to obtain competency in CVC placement, prior to performing the procedure on a patient [2], and the Accreditation Council for Graduate Medical Education mandates that internal medicine residents demonstrate competence in this procedure.

Recent literature suggest that a standardized simulation-based training workshop can improve proficiency in CVC insertion [2]. Training includes both an online pre-test module that reviews anatomy and procedural techniques, hands-on training, and a post-test simulation practical for proficiency. Skills acquired include adherence to sterile technique, familiarity of the CVC kit, and the use of ultrasound in real-time placement of a CVC. Some simulation based programs also include education on dealing with unforeseen complications, as well as the proper procedure for removing a CVC

Methods

House staff, including internal medicine residents and critical care fellows, will be complete a formalized training program including an online module, a simulation training session, and a proficiency simulated exam to assess competency in CVC placement. The curriculum will include a series of didactic lectures and videos, as well as simulation center training models.

First, house staff will undergo a pre-test to assess their ability to safely place a CVC. This will involve a monitored simulated CVC insertion under the supervision of a faculty member or critical care fellow who had previously demonstrated proficiency in this technique. They will be graded on a pass/fail metric using a predefined checklist of critical steps assessing sterility, safety, and success.

Then house staff here will be a dedicated simulation curriculum to teach multiple aspects of the CVC insertion. The first component will be an online component which reviews anatomy, informed consent, sterile gowning and technique, and a review of the procedure highlighting critical steps of the procedure. The hands-on portion of the training will focus on sonographic acquisition of a safe location and real-time guidance of the needle tip into the vessel, choosing the appropriate equipment, insertion using a series of universal checkpoints, and confirmation of placement.

Finally, after completing the curriculum, house staff will then be assessed for competency with a post-test practical demonstration on a simulation model again using a pass/fail metric.

Figure 1: CVC Training Checklist

CENTRAL LINE SIMULATION PRACTICAL

Name:_____ Date:_____

STERILE TECHNIQUE:

- ☐ Wears mask and cap prior to chloroprep
- ☐ Chloropreps for 30 sec in rigorous back and forth motion
- ☐ Hands do not come out of the gown for gloving
- ☐ Places probe cover correctly

KIT PREP:

- ☐ Chooses correct needle and places on non-luerlock syringe
- ☐ Ensures wire is ready for use
- ☐ Identifies the other equipment that they will need to use (dilator, scalpel)
- ☐ Preps the catheter with saline
- ☐ Either locks or caps the proximal and medial ports, leaves distal port open

US

- ☐ Correct Probe used
- ☐ Probe marker lined up with marker on screen
- ☐ Vessel Identified

STICK TECHNIQUE

- ☐ Needle held perpendicular
- ☐ Vessel Accessed
- ☐ Angle lowered while drawing back blood
- ☐ Confirms wire in vessel with needle out

NICK and DILATE

- ☐ Nick is made in parallel with vessel
- ☐ Dilator is held at the end closest to skin/distal end
- ☐ Dilates in the plane of the vessel

PLACE and SECURE CATHETER

- ☐ R U advanced to 15cm
- ☐ Never lets go of wire
- ☐ Sutures both the line and the blue/white piece

Figure 1. CVC Training Checklist. The CVC is broken in a series of components which allows learners to compartmentalize the procedure, learning critical steps throughout the procedure. This checklist focuses on sterile technique, preparation of equipment, ultrasound handling, needle access and wire placement, knick/dilation technique, and catheter placement, securement and dressing. These steps are highlighted in the online component and also during the hands-on training portion during which time they can practice each step until a certain comfort level and familiarity is achieved.

Figure 2. Post-Test Proficiency Evaluation

Central Line Assessment Checklist

Resident: Observer: Date:

Step	Observed	Not Observed
1. Properly positioned patient.	_____	_____
2. Accurately described potential risks of the procedures during obtaining consent: PTX, bleeding, infection, cannulation of an incorrect vessel.	_____	_____
3. Set up the procedure sterilely.	_____	_____
A) Use of barriers. Mask ____; Gown _____; gloves ____. B) Chloroprep: circular/ low vigor _____ Back and forth/ vigorous C) US probe cover: our technique_____ intuitive technique _____		
4. Lined Kit Set up on another table with all necessary equipment including flushes. A) Flushed catheter ports _____; did not flush catheter ports ____ B) Clamped additional ports _____; did not clamp additional ports ____	_____	_____
5. Performed time out.	_____	_____
6. Identified patient vessel.	_____	_____
7. Identified safe location with the ultrasound.	_____	_____
8. Demonstrated appropriate stick technique. A) Angle between US probe & hand: zero (parallel): _____ 0-45 : _____ 46-90: ____	_____	_____
9. Demonstrated wire control (hand NEVER comes off the wire).	_____	_____
10. Identified the wire in the vessel.	_____	_____
11. Demonstrated satisfactory skin nick.	_____	_____
12. Placed dilator at the appropriate angle.	_____	_____
13. Technique for placing the catheter over the wire	_____	_____
14. Checked for return of blood.	_____	_____
15. Care while handling sharps during the entire procedure	_____	_____
16. Placed catheter at appropriate length.	_____	_____
17. Double clicked the device. (white and blue pieces)	_____	_____
18. Demonstrated proper suture technique.	_____	_____
19. Used sterile dressing placement.	_____	_____
20. Disposed of sharps appropriately.	_____	_____
21. Ordered post-procedure CXR.	_____	_____
22. Procedure note and adequacy.	_____	_____

Figure 2. Post-Test Proficiency Evaluation. This form is used when evaluation trainees for CVC placement proficiency. It focuses on the critical steps required for CVC placement including positioning, informed consent, pre-procedure time out, real-time ultrasound guidance of the needle into the vessel (assessing the probe/needle angle), wire confirmation in the vessel, dilation, catheter placement, blood return, securement and dressing. This assessment is used both before and after the comprehensive online and simulated training course.

Figure 3. Ultrasound Images during CVC Insertion

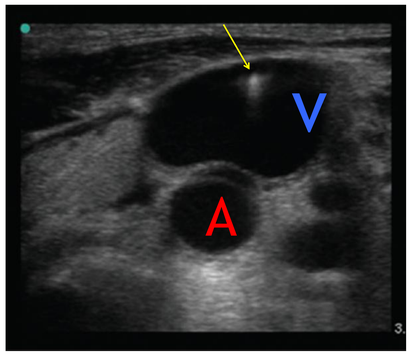

Figure 3a. Transverse sonographic image of the internal jugular vein (V), adjacent to the carotid artery (A). The tip of introducer needle (arrow) is seen inside of lumen of the internal jugular vein. This visualization utilizes an ultrasound technique which includes holding the probe at a narrow angle with the needle, and fanning the probe so that the needle tip is seen entering the vessel in real time.

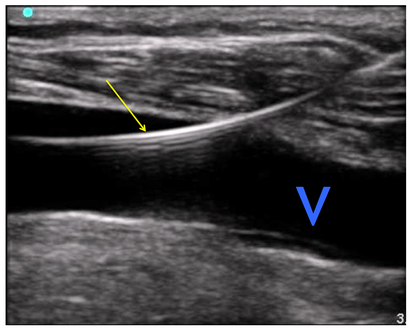

Figure 3b. Longitudinal sonographic image of the guidewire in the internal jugular vein. The guidewire (arrow) is visualized entering internal jugular vein (V), using a linear ultrasound probe. This “confirmation of the wire” is on of the criticl and often missed steps in CVC placement. Proceeding to dilation before confirming venous placement could lead to profounf complications if the carotid artery is unintentioinally cannulated.

Objectives

The objectives of this study are to assess residents’ pre-workshop ability and comfort with CVC placement, undergo a standardized online didactic and hands-on clinical training simulation workshop, and subsequently undergo a proficiency test using simulation models to assess competency. The goal of a standardized training module is to create a universal approach to CVC placement in our institution and improve comfort and technical ability of house staff. We hypothesize that this will reduce complications and improve patient care and safety.

References

1. Merrer J. De Jonghe B., et al. Complications of femoral and subclavian venous catheterization in critically ill patients: a randomized controlled trial. JAMA. 2001; 286(6) 700-707.
2. Alsaad A, Bhide V, Moss J, Silvers S, Johnson M, and Maniaci M. Central line proficiency test outcomes after simulation training versus traditional training to competence. Ann Am Thorac Soc. 2017; Vol 14, No 4, 550-554.