Peripherally Inserted Central Catheters by Nurses using the Sonic Flashlight

David Wang[1,5], Nikhil Amesur[2], Roberta Klatzky[4], Bing Wu[4], Angela Bayless[2],
Christopher Banks[2], Bernadette Mandella[2], Gaurav Shukla[1], George Stetten[1,2,3,5]

[1]Department of Bioengineering, University of Pittsburgh, Pittsburgh PA 15261, USA
[2]University of Pittsburgh Medical Center, Pittsburgh PA 15261, USA
[3]Robotics Institute, Carnegie Mellon University, Pittsburgh PA 15213, USA
[4]Department of Psychology, Carnegie Mellon University, Pittsburgh PA 15213, USA
[5]Department of Biomedical Engineering, Carnegie Mellon University, Pittsburgh PA 15213, USA
http://www.vialab.org

Abstract

Peripherally Inserted Central Catheters (PICCs) are often placed in patients requiring multiple doses of intravenous (IV) medicine or multiple draws of blood samples. These are commonly done by experienced nurses on the IV team, who travel throughout the hospital to place these lines at the patient's bedsides (in lieu of a costly trip to the radiology department). PICC placement is ubiquitiously performed under ultrasound guidance, allowing the clinician visualization of the target vessel prior to needle puncture. We propose here the use of a new ultrasound device for guidance of PICC placement, and demonstrate its feasibility for use by IV team nurses on the hospital floors. We also demonstrate that IV team nurses can adapt to the SF quickly.

Background

Our lab has developed a novel ultrasound device for guiding invasive procedures called the **Sonic Flashlight** (SF). The SF replaces the conventional ultrasound (CUS) monitor with a small display and a semi-reflective/transparent mirror to reflect real-time US images into the body. Looking through the mirror, the virtual US image appears to float beneath the skin, precisely where the scan is being obtained. The SF merges the US image, probe, needle, operator's hands, and patient into the same field of view, making procedures more intuitive. In contrast, CUS displaces hand-eye coordination by forcing the operator to look away from the operating field to see the US display.

Real-Time Tomographic Reflection

The RTTR system functions by fixing the relative geometry of the ultrasound transducer, the display, and a half-silvered mirror to produce a virtual image at the scanned anatomy within the body. Through the half-silvered mirror, the ultrasound image is seen as if it "shines out" from the probe and illuminates the inner tissue. Thus the system has been referred to as the Sonic Flashlight (SF).

A hand viewed through a mirror on the prototype sonic flashlight
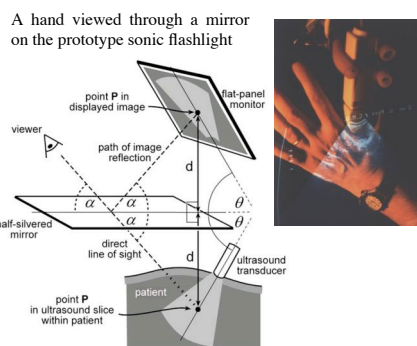
The Clinical Sonic Flashlight

Figure 2 (below) shows the Sonic Flashlight cart. A CUS display is shown, which is available to the operator if the SF is unsuccessful in guiding the PICC placement.

Figure 1 (above) shows the clinical Sonic Flashlight ultrasound probe, wrapped in a sterile bag, ready for use in guidance of PICC placement. The mirror and anti-glare hood are attached outside the bag to prevent image distortion.

References

D. Wang, NB. Amesur, D. Weiser, WM. Chang, AB. Zajko, G. Stetten. Improving Image Quality of the Sonic Flashlight for Venous Access. 107th annual meeting of the American Roentgen Ray Society, May 2007, Orlando, FL.

W. Chang, NB. Amesur, D. Wang, A. Zajko, G. Stetten. First Clinical Trial of the Sonic Flashlight - Guiding Placement of Peripherally Inserted Central Catheters, 2005 meeting of the Radiological Society of North America, November 2005, Chicago, Illinois.

As shown in Figure 3 (right), using the Sonic Flashlight is intuitive and easy. The ultrasound image is shown on the mounted display; when the operator is looking through the mirror at the field of operation, he/she can aim a needle directly at the virtual ultrasound image floating in the target. (Virtual ultrasound image is shown as real image for purposes of demonstration.)
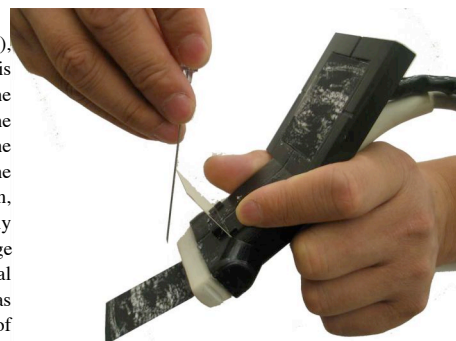
Methods

- We conducted feasibility trials in the interventional radiology suite, in which a trained radiologist successfully used the SF to guide placement of PICCs on patients.
- We recruited and briefly trained two experienced IV team nurses to place PICCs using either the SF or CUS to guide needle insertion.
- During a trial, the nurse scanned the patient's upper arm with either the SF or CUS to insert a needle into either the basilic, brachial, or cephalic veins.
- If vascular access was unsuccessful after three attempts with the SF, the operator reverted to CUS.
- If successful access was gained in the selected vein, the procedure continued as in a standard PICC line procedure.
- We recorded the number of needle punctures needed to see blood return from the target vessels during the SF and CUS cases.

Results

Operator	Modality	Success on 1st puncture	Success on 2nd puncture	Success on 3+ punctures	X^2_2
Nurse #1	Conventional Ultrasound (CUS)	29/30 97%	1/30 3%	0/30 0%	2.17
	Sonic Flashlight (SF)	19/20 95%	0/20 0%	1/20 5%	
Nurse #2	Conventional Ultrasound (CUS)	23/30 77%	3/30 10%	4/30 13%	2.59
	Sonic Flashlight (SF)	14/20 70%	5/20 25%	1/20 5%	

Neither chi-square analysis shows a significant difference (at the p<0.05 level, chi-square(2) > 5.99) between the Sonic Flashlight and conventional ultrasound, meaning that **experienced nurses quickly adapt to the SF without performance decrement**.

Conclusion and Future Work

We have successfully shown that experienced nurses can quickly adapt to using the Sonic Flashlight for guidance of PICC placement without performance decrement. Residents and nurses alike exhibit a significant learning curve when training for vascular access. The Sonic Flashlight should shorten learning time and increase success rates of these procedures. Current studies are ongoing to demonstrate improved performance among less experienced residents and nurses.