Sharp, R., Gordon, A., Mikocka-Walus, A., Childs, J., Grech, C., Cummings, M. and Esterman, A., 2013. Vein measurement by peripherally inserted central catheter nurses using ultrasound: a reliability study. *Journal of the Association for Vascular Access, 18*(4), pp.234-238.
http://www.sciencedirect.com/science/article/pii/S1552885513001347

Vein measurement by Peripherally Inserted Central Catheter (PICC) nurses using ultrasound – a reliability study.

Rebecca Sharp, BN, BHSc (Hons)
School of Nursing and Midwifery, University of South Australia, Adelaide, Australia
Andrea Gordon, PhD
School of Nursing and Midwifery, University of South Australia, Adelaide, Australia
Antonina Mikocka-Walus, PhD
University of York, York, United Kingdom
Jessie Childs, BHSc (Hons), GradDipSon
School of Health Sciences (Medical Sonography), University of South Australia, Adelaide, Australia
Carol Grech, PhD
School of Nursing and Midwifery, University of South Australia, Adelaide, Australia
Melita Cummings, BN
Royal Adelaide Hospital, Adelaide, Australia
Adrian Esterman, PhD
School of Nursing and Midwifery, University of South Australia, Adelaide, Australia

Background: Peripherally Inserted Central Catheters (PICC's) are increasingly inserted by trained Registered Nurses (PICC nurses), necessitating the development of specialised skills such as the use of ultrasound. The selection of an adequate sized vein is an important factor in reducing adverse events such as deep vein thrombosis. However, PICC nurses may receive minimal training in the use of ultrasound for vein measurement.
Objective: To demonstrate the reliability of a vein measurement protocol using ultrasound by a PICC nurse trained in sonography.
Method: The diameter of the basilic, brachial and cephalic veins in the left arms of healthy participants (n=12) were measured using ultrasound by a PICC nurse and a sonographer. The PICC nurse performed the measurement twice and the sonographer once; the PICC nurse's results were compared for intra-rater reliability and compared to the sonographer for inter-rater reliability. The results were analysed using intraclass correlation coefficients (ICC).
Results: Inter-rater reliability between the PICC nurse and the sonographer was adequate, the ICC for the brachial vein was 0.60 (95% CI 0.06-0.87), basilic vein ICC 0.87 (95% CI 0.58-0.96) and cephalic vein ICC 0.77 (95% CI 0.39-0.93). Intra–rater reliability of the PICC nurse was higher; the ICC for the brachial vein was 0.80 (95% CI 0.44-0.94), basilic vein ICC 0.92 (95% CI 0.67-0.98) and cephalic vein ICC 0.78 (95% CI 0.40-0.93).
Conclusion: Using a suitable protocol**, t**he PICC nurse was able to measure vein diameter reliably when compared to the sonographer and consistently replicate these results.

Introduction

Peripherally inserted central catheters (PICCs) are used in a range of patient groups for medium to long-term intravenous therapy. These vascular access devices are inserted above the ante- cubital fossa region into the basilic, brachial or cephalic vein and threaded through until the tip lies in the superior vena cava thereby giving access to the central circulation.[1]It is considered best-practice to insert PICCs using two-dimensional (2-D) ultrasound imaging guidance. [1,2] The use of ultrasound increases PICC insertion success rates and reduces adverse events when compared to insertion using palpation and anatomical landmarks. [3–5]

Deep vein thrombosis (DVT) is a painful adverse event associated with PICC placement which often results in catheter removal and can lead to acute, life-threatening events such as pulmonary embolism and ongoing complications including post-thrombotic syndrome. [6–8]Incident rates of symptomatic DVT (where there is pain and swelling) account for between 2-20% of PICC insertions. [9–11]The pathogenesis of DVT can be explained by Virchow's triad, an interplay of three elements which increase the risk of thrombus; endothelial damage to the vein intimae, interruption in blood flow (stasis) and the hypercoagulable state of the patient.[7,12] Stasis is an important modifiable risk factor for DVT which has led to the recommendation that the smallest diameter PICC that meets the infusion requirements of the patientbe inserted into the largest vein. [1, 13] The measurement of patient veins using ultrasound is an important element in pre-insertion assessment. As PICC insertion is predominantly performed by PICC nurses, it is important that these health professionals are competent in the use of ultrasound for this purpose. [14,15]

Ultrasound is a valid tool for vein measurement, used in other clinical areas to determine vein diameter such as prior to arteriovenous fistula creation for dialysis. [16]Like other clinical

procedures involving measurement, it is important to ensure that the measurements taken are reliable. However, to date, no reliability studies have been published that establish that vein measurements taken by PICC nurses using ultrasound can be undertaken consistently. This study aims to demonstrate the reliability of a vein measurement protocol by a PICC nurse compared to a qualified and experienced sonographer.

Design

Participants

A convenience sample was recruited consisting of staff and higher degree students in a faculty of health science located in a large Australian university. There were no formal inclusion/exclusion criteria.

Ethics

Ethics approval was granted by the university's Human Research Ethics Committee prior to the study's commencement and written consent was obtained from all participants.

Raters

The first rater was an accredited medical sonographer with extensive clinical and teaching experience. The second rater was a PICC nurse with 10 years experience at a major metropolitan teaching hospital.

Procedure

The PICC nurse and sonographer both measured veins in the participant's left arm which was chosen for convenience. Participants were rested in a supine position on a bed with their arm extended and supported at a 90 degree angle by a platform. The arm was in a natural state

without tourniquet. The participants were asked to bend their arm and a mark was placed in the crease of the bend at the elbow. Using a measuring tape, a further mark was placed on the skin 10cm proximal to the mark at the elbow crease to give both raters a mark to align the transducer to. A portable SonoSite™ S-Series ultrasound (SonoSite, Bothell, WA) with a 13-6 MHz linear probe was used and set to the inbuilt vein setting. The transducer was manoeuvred along the mark and angled from left to right to obtain the clearest image of the vein and reduce artefact in the image. Light transducer pressure was used to reduce vein compression and gain/depth was optimised for each image. The basilic, brachial and cephalic veins were scanned in transverse section. Where two brachial veins were present, the larger diameter vein was measured.

Each vein was measured in an anterior to posterior dimension using the machine's inbuilt callipers. The calliper was positioned with the top of the cross bar of the anterior calliper aligned with the inside of the top echogenic vein edge and the bottom of the cross bar of the posterior calliper aligned with the inside of the bottom echogenic vein edge (figures 1).

Figure 1: Ultrasound image of basilic
vein measurement with callipers. Image by authors.

The vein was measured in an axial plane due to the greater accuracy of the resolution in this dimension.[17] The echogenic periphery of the vein was removed to avoid ambiguity in regards to adjacent soft tissue.

This technique was repeated for the basilic, brachial and cephalic veins. Once the first rater (PICC nurse) had concluded vein measurement, the sonographer (who was blinded to the results of the PICC nurse) performed the same measurements. Finally, the PICC nurse repeated measurements on the three veins of participants. The PICC nurse performed the measurement twice and the sonographer once. The first measurements obtained by the PICC nurse were compared to the sonographer's to determine inter-rater reliability and the two sets of measurements performed by the PICC nurse were compared for intra-rater reliability.

Statistical analysis

A power analysis to determine sample size needed was conducted using PASS 11 (NCSS, Utah, USA). A sample size of 12 participants with 2 observations per subject was required to achieve 80% power to detect an intra or inter-class correlation of 0.70 with a 0.05 two-sided significance level.

Mean diameter and 95% confidence intervals were calculated for each vein. Inter and intra-rater reliability was measured by intraclass correlation coefficient (ICC) using a two-way mixed effects model of absolute agreement assessing the reliability of single ratings. The ICC value lies between 0 and 1, with a low ICC (closer to 0) suggesting poor agreement and a value of 1 considered perfect agreement. In this study, ICC results higher than 0.60 indicated adequate agreement.[18] The ICC and 95 % CI were calculated for each of the three veins using the statistical package MedCalc for Windows, version 12 (MedCalc Software, Ostend, Belgium).

Results

There were 12 participants (7 males, 5 females) aged between 23-64 years old in the study.

Inter-rater reliability

The first vein diameter measurements obtained by the PICC nurse ranged from 1.60-3.90 mm for the brachial vein (mean 2.57 mm; 95% CI 2.20-2.93 mm), 2.30-6.90 mm for the basilic vein (mean 4.63 mm; 95% CI 3.75-5.51 mm) and 1.90-4.80 mm for the cephalic vein (mean 3.26 mm; 95% CI 2.66-3.86 mm). The measurements obtained by the sonographer for the same participants ranged from 1.00-4.10mm for the brachial vein (mean 2.64 mm; 95% CI 2.16-3.13 mm), 2.10-7.20 mm for the basilic vein (mean 5.00mm; 95% CI 4.12-5.90mm) and 1.60-4.80 mm for the cephalic vein (mean 3.51 mm; 95% CI 2.95-4.06 mm).

The inter-rater reliability between the measurements obtained by the PICC nurse and the sonographer was moderate or higher, with ICC values for all three veins equal to or greater than 0.60 (Table 1). The highest ICC was demonstrated with the basilic vein, followed by the cephalic and brachial (Table 1). The confidence interval range for the brachial vein was large (95% CI 0.06-0.87), perhaps due to the small sample size and the difficulty locating and visualising this deep vein.

Table 1: Inter-rater reliability of vein measurement

Vein	ICC	95% Confidence Interval
Brachial	0.60	0.06-0.87
Basilic	0.87	0.58-0.96
Cephalic	0.77	0.39-0.93

ICC= Intraclass Correlation Coefficient (two-way mixed effects model of absolute agreement)

Intra-rater reliability

The PICC nurse's measurements for brachial vein diameter ranged from 1.60-3.90 mm first measure (mean 2.57mm; 95% CI 2.20-2.93 mm) and 1.00-3.40mm for the second measure (mean 2.58mm; 95% CI 2.18-2.99). The basilic vein diameter ranged 2.30-6.90 mm first measure (mean 4.63mm; 95% CI 3.75-5.51 mm) and 2.70-6.90 mm for the second measure (mean 4.94 mm; 95% CI 4.18-5.71 mm).The cephalic vein varied between 1.90-4.80 mm (mean 3.26 mm; 95% CI 2.66-3.86 mm) first measure and 1.70-4.70 mm (mean 3.37; 95% CI 2.89-3.84 mm) for the second measure.

The PICC nurse was able to reliably perform the same measurements with high ICC for all veins (Table 2).The basilic vein had an ICC of 0.92 which demonstrates almost perfect agreement. The brachial and cephalic veins were lower, but still showed substantial agreement (Table 2).

Table 2: Intra-rater reliability of vein measurement

Vein	ICC	95% Confidence Interval
Brachial	0.80	0.44-0.94
Basilic	0.92	0.67-0.98
Cephalic	0.78	0.40-0.93

ICC= Intraclass Correlation Coefficient (two-way mixed effects model of absolute agreement)

Discussion

This is the first study to investigate the reliability of vein measurement by a PICC nurse using ultrasound. Acceptable inter-rater and high intra-rater reliability was achieved indicating that the PICC nurse was able to perform measurements consistently when compared to a sonographer and when repeating measurements.

The highest reliability (both inter and intra-rater) in this study was found with the basilic vein. This may be explained by the superficial location and often large diameter of this vein, making it easy to visualise and measure. [7,19] The ICCs for the brachial and cephalic veins were inconsistent when comparing inter and intra-rater reliability. The inter-rater reliability of the cephalic vein was higher than that of the brachial vein, perhaps due to the often superficial position of the cephalic vein, making identification and measurement easier. [19] The reverse was found with intra-rater results. The brachial vein had a higher ICC when compared to the cephalic. This may be explained by the PICC nurse's experience visualising this vein which is often used when the basilic is contra-indicated for PICC insertion.[7,20]

These findings may suggest that PICC nurses who have sufficient and appropriate training are competent in the use of ultrasound to visualise and measure vein diameter. However, these results can't be generalized to other PICC nurses due to the small number of participants in the study and because training for PICC nurses differs widely.

A taskforce established at the World Congress of Vascular Access (WoCoVa) found that there is a lack of standardised training required to be completed by Registered Nurses to undertake PICC insertion[21]Although organisations such as the Infusion Nurses Society state that there is a need for PICC nurses to ensure they are competent in their scope of practice, which would include the use of ultrasound, the training required to achieve this is not clearly

mandated by a professional organisation.[1,14,21]The training undertaken by PICC nurses varies; some inserters are trained by employers whilst other practitioners attend one-day workshops offered by private companies or direct instruction from representatives of ultrasound manufacturers.

Differences in the training offered to PICC nurses suggest that skill level may vary. Conversely, sonographers undertake standardised training in the use of ultrasound which incorporates theoretical and clinical elements. In Australia this comprises an accredited postgraduate diploma or masters degree after an undergraduate degree in Health Sciences. The clinical element of these courses requires sonography students to complete over 900 clinical hours with multiple practical assessments to achieve competence.[22]

The PICC nurse in the present study self-initiated the development of a clinical based PICC insertion credentialing program after completion of a 5 day theory-based PICC course. Firstly, ultrasound training was undertaken for several weeks in the Radiology department. This incorporated ultrasound physics, the identification of relevant anatomical structures on healthy volunteers (other staff members) and the identification of abnormal anatomy and thrombosis. Finally, the PICC nurse undertook several months of directly supervised PICC insertion using ultrasound with an Interventional Radiologist. This combination of didactic and clinical training with supervision was recommended by the WoCoVa task force as important elements of training programs for PICC insertion. [21]

The present study highlights the importance of appropriate training for PICC nurses so they are able to perform ultrasound to consistently measure vein diameter. This is an important component of pre-insertion vein assessment allowing the identification of the largest and most appropriate vein to catheterise to reduce the risk of adverse events for the patient.[15,23] PICC insertion training needs to incorporate the use of ultrasound as a tool for vein

assessment purposes. Further this is an important element to consider in the development of future competency standards for PICC nurses.

Limitations

Although powered to detect a relatively high level of reliability compared to zero, the present study did utilise a small sample size. This coupled with the difficulties visualising small and deep veins may explain the wide confidence intervals for some of the reliability coefficients. Nonetheless the primary interest in this study was the size of the co-efficient not its accuracy. Further the PICC nurse is highly trained with more than 10 years experience which makes generalising to other PICC nurses with different training and skill levels difficult. Finally, the present study included only healthy volunteers and thus findings may not necessarily be generalisable to a hospital population. Future studies need to be conducted in a hospital population to ascertain the diameters of veins commonly used for PICC insertion.

Conclusion

This study has indicated that a suitably trained PICC nurse can reliably measure vein diameter using ultrasound. It is important that PICC nurses undergo appropriate training with ongoing support to ensure they are competent in the technology used for PICC insertion to foster improved patient outcomes.

References

1. Infusion Nurses Society. Infusion nursing standards of practice. *J Infus Nurs*. 2011; 34(Suppl 1):S1–S110.

2. Association for Vascular Access. The use of ultrasound guidance by Registered Nurses for Central Venous Catheter insertion. Available at: https://www.avainfo.org/website/download.asp?id=279996.

3. Krstenic WJ, Brealey S, Gaikwad S, Maraveyas A. The Effectiveness of Nurse Led 2-D Ultrasound Guided Insertion of Peripherally Inserted Central Catheters in Adult Patients: A Systematic Review. *J Assoc Vasc Access*. 2008;13(3):120–125. doi:10.2309/java.13-3-4.

4. Johnson M, McKenzie L, Tussey S, Jacobs H, Couch C. Portable ultrasound: A cost-effective process improvement tool for PICC placement. *Nurs Manag*. 2009;40(1):43–47.

5. Stokowski G, Steele D, Wilson D. The use of ultrasound to improve practice and reduce complication rates in peripherally inserted central catheter insertions: final report of investigation. *J Infus Nurs*. 2009;32(3):145–155.

6. Ong B, Gibbs H, Catchpole I, Hetherington R, Harper J. Peripherally inserted central catheters and upper extremity deep vein thrombosis. *Australas Radiol*. 2006;50(5):451–454. doi:10.1111/j.1440-1673.2006.01623.x.

7. Dawson RB. PICC Zone Insertion Method ™ (ZIM™): A Systematic Approach to Determine the Ideal Insertion Site for PICCs in the Upper Arm. *J Assoc Vasc Access*. 2011;16(3):156–165. doi:10.2309/java.16-3-5.

8. Philpot P, Griffiths V. The peripherally inserted central catheter. *Nurs Stand*. 17(44):39–46.

9. Chemaly RF, de Parres JB, Rehm SJ, et al. Venous thrombosis associated with peripherally inserted central catheters: a retrospective analysis of the Cleveland Clinic experience. *Clin Infect Dis*. 2002;34(9):1179–1183.

10. Tran H, Arellano M, Chamsuddin A, et al. Deep venous thromboses in patients with hematological malignancies after peripherally inserted central venous catheters. *Leuk Lymphoma*. 2010;51(8):1473–1477. doi:10.3109/10428194.2010.481065.

11. Trerotola SO, Stavropoulos SW, Mondschein JI, et al. Triple-Lumen Peripherally Inserted Central Catheter in Patients in the Critical Care Unit: Prospective Evaluation1. *Radiology*. 2010;256(1):312–320.

12. Yacopetti N. Central venous catheter-related thrombosis: a systematic review. *J Infus Nurs*. 2008;31(4):241–248.

13. Pieger-Mooney S. Innovations in central vascular access device insertion. *J Infus Nurs*. 2005;28(3S):S7–S12.

14. Moureau N. Vascular safety: It's all about PICCs. *Nurs Manag*. 2006;37(5):22–27.

15. Moureau NL, Trick N, Nifong T, et al. Vessel health and preservation (Part 1): A new evidence-based approach to vascular access selection and management. *J Vasc Access*. 2012;13(3):351–356. doi:10.5301/jva.5000042.

16. Kumar S, Seward J, Wilcox A, Torella F. Influence of muscle training on resting blood flow and forearm vessel diameter in patients with chronic renal failure. *Br J Surg*. 2010;97(6):835–838. doi:10.1002/bjs.7004.

17. Kremkau F. *Sonography Principles and Instruments, (Diagnostic Ultrasound: Principles & Instruments)*. 8th ed. Saunders; 2010.

18. Landis R, Koch G. The Measurement of Observer Agreement for Categorical Data. *Biometrics*. 1977;33(1).

19. Pieters PC, Tisnado J, Mauro MA. *Venous Catheters: A Practical Manual*. Thieme; 2003.

20. Evans RS, Sharp J, Linford L, et al. Risk of Symptomatic DVT Associated With Peripherally Inserted Central Catheters. *CHEST*. 2010;138(4):803. doi:10.1378/chest.10-0154.

21. Moureau N, Lamperti M, Kelly LJ, et al. Evidence-based consensus on the insertion of central venous access devices: definition of minimal requirements for training. *Br J Anaesth*. 2013;110(3):347–356. doi:10.1093/bja/aes499.

22. Australian Sonographers Association. Becoming a sonographer. 2013. Available at: http://www.a-s-a.com.au/cms/?c=96&t=becoming-a-sonographer.

23. Meyer BM. Managing Peripherally Inserted Central Catheter Thrombosis Risk: A Guide for Clinical Best Practice. *J Assoc Vasc Access*. 2011;16(3):144–147. doi:10.2309/java.16-3-3.