Medical student Ultra Sound Training – a MUST

Chikezie Dean Okereke[2], Patrick Tung[2], Asoka Weerasinghe[2]

**Corresponding author:** Mr Asoka Weerasinghe asoka.weerasinghe@midyorks.nhs.uk
**Institution:** 2. Mid Yorkshire Hospitals NHS Trust
**Categories:** Students/Trainees, Teaching and Learning, Technology

Received: 29/05/2017
Published: 05/06/2017

**Abstract**

**Background**

Use of ultrasound (US) to guide invasive procedures is steadily growing. The increased accuracy, decreased complications and overall patient and clinician satisfaction of ultrasound-guided procedures makes it a useful skill to acquire. In this study, we explored whether basic procedural ultrasound training, specifically addressing vascular access, can be taught to medical students by focusing on generic skills that could be individually assessed.

**Methods**

215 5th year medical students were enrolled in the session. The session involved 70 minutes of didactic teaching and 140 minutes of supervised scanning followed by an assessment. The training was on ultrasound compatible phantoms and simulated human patients using a linear transducer.

**Results**

93% (n=199) of students were able to optimize the image and visualize the relevant structures independently. 86% (n = 184) were able to insert the needle into the vessel of the training block independently using transverse view while 89% (n=198) were able perform the same independently with longitudinal view.

**Discussion**

The majority of students were able to demonstrate this skill with limited training. This study suggests that ultrasound skills requiring hand-eye co-ordination such as probe stabilization and real time needle insertion can be more intensively targeted in procedural ultrasound training programs designed for all medical students.

**Keywords:** Ultrasound, Undergraduate, Intravenous access
Introduction

Ultrasound in medical practice is often seen as technically challenging. The knobology remains challenging and an enigma for clinicians. Most clinicians however, believe that ultrasound represents the future of clinical day-to-day medical practice and as clinical medical educators interested in ultrasound medicine we feel it is important that we develop ultrasound education programs to ensure that future clinicians embrace and utilize ultrasound in their day-to-day clinical practice.

Over the last decade, Ultrasound has increasingly been used to guide many invasive procedures (Terkawi et al. 2013). There is not much doubt that ultrasound guided vascular access significantly increases safety, effectiveness and efficiency of vascular access by increasing the probability of needle placement upon first pass while decreasing well recognised complications (Lamperti et al 2012). It is for this reason that NICE has recommended that ultrasound guidance is used for all elective central venous access, and considered for most emergency central venous catheterizations (NICE, 2002).

Recent evidence suggests that ultrasound guided arterial cannulation can help reduce the number of attempts, shorten the procedure time, and increases the success rate, even in children (Kumar et al. 2009). This is particularly true when the pulsation of the artery is not evident, or when the artery is small (Shiloh et al. 2011). Similarly ultrasound-guided peripheral vascular access has been shown to be more successful in patients who have difficult intravenous access (for example intravenous drug users) as it requires less time, decreases the number of unsuccessful attempts and improves patient satisfaction (Constantino et al. 2003). US guidance has also been shown to improve the success rate of peripheral vascular access in children with difficult or very difficult vascular access (Oakley et al. 2010).

Senior clinicians in Emergency Medicine and Anaesthesiology now routinely use ultrasound guidance to obtain difficult intra venous access (IVA) and arterial sampling (ABG). However junior doctors who are usually the first contact in these challenging situations are still, for the most part, expected to perform the difficult peripheral IVA and ABG sampling without ultrasound.

The purpose of the course was to see if medical students on a short course, under the guidance of senior clinicians with ultrasound knowledge, would be able to learn basic and procedural ultrasound that would allow them carry out some day-to-day procedures. We also wanted to see whether the skill of ultrasound guided peripheral venous cannulation and arterial blood gas sampling could be individually assessed. We felt that training and assessment by senior clinicians was more likely to give the students more confidence. It was also to debunk the view prevalent among students and junior trainees that the use of ultrasound is only for trained radiology staff.

The ethics committee did not feel that formal ethics approval would be necessary as this was considered normal clinical practice.

Method

This was a single center study. All 5th year medical students of the School of Medicine University of Leeds who were on clinical placements at Mid-Yorkshire Hospitals NHS Trust were voluntarily enrolled in the course. A pre-course questionnaire was given to students to establish their previous ultrasound training. The course structure was divided three parts comprising...
1. Seventy minutes of didactic teaching on ultrasound physics, knobology, procedure and governance.

1. One hundred and forty minutes of supervised scan practice with an instructor: student ratio of 1:3 maximum for the scan practice.

1. Formative students’ assessment on nine components (Figure 1) using a 3-point scale as per Kirk Patrick level 2 model using an ultrasound training block.

The training was done mostly on ultrasound training blocks and phantoms using a linear transducer. We also used simulated patients to demonstrate the veins and the arteries ensuring conceptualization of the teaching and training.

The nine-components comprised of the student selecting and stabilizing the correct transducer, acquiring and optimizing the correct image, inserting the needle to the vessel on the phantom (on both transverse and longitudinal views), and finally identifying the vein and the artery ultrasonically on a volunteer’s upper limb.

Results

Two hundred and fifteen students were enrolled in the course of which 193 (94%) admitted that they have had no previous training in ultrasound.

The result of the course end assessment showed that 93% of the students (n=199) were able to optimize the image, and acquire longitudinal and transverse images of the vessel independently on the ultrasound-training block. The remaining 7% (n=16) achieved this standard with minimal prompt by the assessor. 95% (n=205) of the students were able to differentiate the artery from the vein ultrasonically independently on the volunteer’s upper limb. The remaining 5% (n=10) achieved this standard with minimal prompt by the assessor.

91% (n=194) were able to stabilize the transducer independently on the training block. 86% (n = 184) were able to insert the needle into the vessel of the training block independently using transverse view while observing the needle tip in real time using a single operator technique and 89% (n=190) were able perform the same independently with longitudinal view. The rest of the students were able to demonstrate these skills with minimal instruction.

The course evaluation (anonymised) showed that the program was well received and was overall perceived by the students to have enhanced their medical education. Our course feedback also suggested that the students were enthused by the course and felt able to apply the learning in their future placements upon graduation.

Discussion

This was a performance-based assessment measuring what potential doctors can do in their professional practice as opposed to a competence-based assessment, which measures what doctors can do in the controlled representation of professional practice. In general, all assessments in medical education require evidence of validity to be interpreted meaningfully. The validity is variously measured as content validity; construct validity, concurrent or criterion validity and predictive validity. In the context of medical assessments, validity represents the meaning of the test scores and examines what the college has determined as requisite i.e. the trainee fulfils the requirement when they satisfy the examiners. It should reflect actual knowledge and performance. This was not the case here given that this was a single procedure with defined outcome.
Our course utilized the concept of direct observation of a practical assessment method (DOPS). We know that a DOPS can be used formatively and summatively. Through the training session, the trainer independently graded each student on specific practice items, specifically, the selection of the appropriate ultrasound probe, handling of the probe adjusting gain depth and the focal zones and ability to penetrate and withdraw blood during cannulation and arterial sampling. We used the DOPS in both context and also incorporated feedback to the students.

There are, as far as we are aware, no published data with regard to an acceptable number of first pass image optimization on phantoms and live volunteers by trainees. We feel however, that our results showing a greater than 90% success rate in students of whom the vast majority had no prior ultrasound training experience is very significant and important.

Ultrasound training has been integrated in the curriculum of some medical schools in the United States (Oakley et al.2010) The study in question however addressed a large section of ultrasound training and modules aimed at multiple physician practice at qualification and were run over a four-year period. Interestingly the program, although it addressed the issue of ultrasound-guided procedures, did not specifically address the issue of ultrasound guided peripheral venous cannulation or arterial puncture such as we did on our training courses.

There have also been a number of articles that have looked at courses, which addressed medical student introduction to ultrasound. These articles however appear to have in the main looked at the feasibility of student understanding and application of ultrasound in a diagnostic sense (diagnostic scanning) and in most cases the use of focused abdominal ultrasound for trauma (FAST) scans (Dickerson et al.2016; Gogalniceanu et al.2010; Arger et al.2005). In our case, we looked at and addressed procedural ultrasound training. It is also important to note that none of the articles we reviewed carried out formal assessment at the end of the course to assess the competency, if any, gained during the course. We believe this to be a major strength with regard to your study. The fact that most of the students were able to carry out the tasks at the end of the training session confirmed to us that the course was successful in achieving its main objective.

Most medical educators and especially educators in diagnostic and procedural specialties believe that ultrasound training for trainees is essential. Some educators have long argued that medical students should be introduced to and prepared as early as possible in ultrasound medicine (Hoppmann et al 2011). However, as stated above, these have in the main addressed the issue of diagnostic ultrasound. We would argue and have demonstrated, we believe that teaching procedural ultrasound to medical students is equally as important and we feel will better prepare them for the challenges of day-to-day practice such as with difficult cannulation and arterial blood sampling. This overall will ensure that the patients receive the best available care and complications are minimized.

Benefits of the Training Programme

Our study has shown that ultrasound based procedures such as arterial puncture and peripheral venous cannulation can be successfully and easily introduced to medical students. It shows that the students can quickly learn the procedure with minimal faculty input. In our session we have borrowed on the pyramid of Miller (Miller et al 1990) and tried to show the relation between educational goals and professional performance. We have started by demonstrating the facts and then shown the students how to apply the facts. Finally we addressed the issue of skills and behaviour by allowing the students to demonstrate what they can do in the controlled environment. It is now up to the student to perform the task in reality and this will show that the student has reached the level of beginning professional performance. This is important because ultrasound is growing and the value of point of care ultrasound in improving the patients care, safety and journey continues to mount, involvement of the medical students at an early stage in the use of ultrasound especially the basic handling of probes means that further use of ultrasound on graduation and in postgraduate medicine will become seamless.
Conclusion

To the best of our knowledge this is the first ever procedural ultrasound course conducted in the UK for 5\textsuperscript{th} year medical students. As the end of the training assessment showed, the vast majority of students were able to achieve image optimization and visualize the relevant structures independently at the end of the training program. The students found that skills requiring hand-eye co-ordination such as probe stabilization and inserting the needle while observing the needle tip in real time were more challenging. These areas can be targeted more intensively when teaching medical students extended ultrasound-guided procedures in the future. We also believe that we have shown that even with procedural ultrasound, early medical students’ exposure is a positive in the utility of ultrasound in expanding medical education.

Limitations

We feel that if there was one main defined limitation in this study, it is that the study was not conducted in a real world setting and as such one may argue that any learning in the controlled environment may not be translated into the clinical setting.

Another limitation that we could identify is that we utilized phantoms. We would accept that the use of phantoms can be expensive and often may not provide dynamic and life like images. However, we did use volunteers upon whom the students were able to anatomically localize the veins and the arteries. Using the volunteers for venipuncture or arterial sampling would in our view have been unethical.

Take Home Messages

- Basic procedural ultrasound skills especially ultrasound guided vascular access can be successfully taught to fifth year medical students through a short training programme.
- It can also be incorporated into Undergraduate Medical Curriculum successfully.
- This training will equip the next generation of doctors of this valuable life saving skill.

Notes On Contributors

Mr Asoka Weerasinghe is an Emergency Physician with sub-specialty interest in Medical Ultrasound. He has a Masters Degree on Medical Ultrasound and his key interest is making procedures safer using point of care ultrasound. In addition to MUST he has co created other ultrasound teaching programmes such as Junior doctor Ultrasound Teaching (JUST), Sonography assisted Lumbar puncture Training (SALT) etc. At present he is the Education Lead for Point of Care Ultrasound for the Mid Yorkshire Hospitals NHS Trust and serves in the Undergraduate Ultrasound Curriculum Steering Group at Leeds Medical School which looks after the integration of Ultrasound in to the Undergraduate Curriculum. He also serves in the Ultrasound Committee in European Society for Emergency Medicine.

Dr Patrick Tung is an Emergency Physician with special interests in Undergraduate Education and Medical Ultrasound. He is the Undergraduate Tutor for Mid Yorkshire NHS Trust and also conducts simulation training for medical students. He also has a PgC in Medical Ultrasound. At present he serves in the Undergraduate Ultrasound Curriculum Steering Group at Leeds Medical School which looks after the integration of Ultrasound in to the
Undergraduate Curriculum.

Mr Chikezie Dean Okereke is an Emergency Physician with a Masters Degree in Medical Education. His main role is to oversee the creation of the teaching/learning and assessment materials to ensure that the teaching methodology is sound.

CDO was part of the study concept and design. He performed the literature search, appraised the relevant literature and was responsible for the drafting and the final write-up of the manuscript. PT & AW were part of the study concept and they collated and analyzed the data and prepared the article for submission.

Acknowledgements

Department of Medical Education at Mid Yorkshire Hospitals NHS Trust
Leeds Medical School

Bibliography/References

1. Terkawi AS, Karakitsos D, Elbarbary M, Blaivas M, Durieux ME 2013. Ultrasound for the Anesthesiologists: Present and Future, Scientific World Journal. 683685.

https://doi.org/10.1155/2013/683685

2. Lamperti M, Bodenham AR, Pittiruti M, et al 2012. International evidence-based recommendations on ultrasound-guided vascular access. Intensive Care Medicine; 38:1105–1117. [PubMed]

https://doi.org/10.1007/s00134-012-2597-x

3. National Institute for Clinical Excellence. Guidance on the use of ultrasound locating devices for placing central venous catheters. London: NICE, 2002, [NICE Technology Appraisal No 49].

4. Kumar A, Chuan A. Ultrasound guided vascular access: efficacy and safety2009. Best Practice and Research; 23(3):299–311. [PubMed]

5. Shiloh A, Savel E, Paulin L (2011) Ultrasound-guided catheterization of the radial artery: a systematic review and meta-analysis of randomized controlled trials. Chest 139:524–529

https://doi.org/10.1378/chest.10-0919

6. Constantino TG, Fojük JP 2003. Success rate of peripheral IV catheter insertion by emergency physicians using ultrasound guidance. Ann Emerg Med; 46:456–461.

7. Oakley E, Wong A-M 2010, Ultrasound-assisted peripheral vascular access in a paediatric ED: paediatric emergency medicine. Emergency Medicine Australasia; 22(2):166–170. [PubMed]

https://doi.org/10.1111/j.1742-6723.2010.01281.x
8. Dickerson J, Paul K, Vila P, Whiticar R 2016. The role for peer-assisted US teaching in medical school, teaching US in a curricular course according to certified EFSUMB standards during undergraduate medical education: a prospective study; The Clinical Teacher; 13: 1-5

9. Gogalniceanu P, Sheena Y, Kashef E, Purkayastha S, Darzi A, Paraskeva P 2010. Is basic emergency ultrasound training feasible as part of standard undergraduate medical education? J Surg Educ; 67 (3): 152-6.

https://doi.org/10.1016/j.jsurg.2010.02.008

10. Arger PH, Schultz SM, Sehgal CM et al 2005; Teaching Medical Students Diagnostic Sonography; J Ultrasound Med; 24 (10): 1365-1369.

https://doi.org/10.7863/jum.2005.24.10.1365

11. Hoppmann R A, Rao V V, Poston M B et al 2011. An integrated ultrasound curriculum (iUSC) for medical students: 4-year experience; Crit Ultrasound J 3:1-12

https://doi.org/10.1007/s13089-011-0052-9

12. Miller GE. The assessment of clinical skills/competence/performance 1990. Acad Med: S63-7

Appendices

Figure 1

**Medical student Ultra Sound Training – (Date..)**

US guided Peripheral IVA & ABG Sampling Training 5th Year Medical students at MYHT

Formative Assessment Form

| Objectives                                           | Unable to Achieve despite prompt | Achieved with prompt | Achieved Independently |
|------------------------------------------------------|----------------------------------|----------------------|------------------------|
| 1) Selects the correct transducer (Linear)           |                                  |                      |                        |
| 2) Optimizes the images on the US training block     |                                  |                      |                        |
| 3) Stabilizes the transducer on the US training block|                                  |                      |                        |
| 4) Acquires longitudinal and transverse images of the vessels of US training block |                                  |                      |                        |
|   |   |   |
|---|---|---|
| 5) Inserts the needle into the vessel/s of the US training block using the ultrasound as a guide Demonstrates that the student has the knowledge and the skill to keep the needle tip in vision all the time (Hand - eye coordination) TS – Transducer follows the needle |   |   |
| 6) LS – Needle follows the transducer |   |   |
| 7) Differentiates the artery from vein by explaining the ultrasound differences in texture and appearance - upper limb only (either on each other or explains verbally) |   |   |
| 8) Disposes the sharps in a safe and controlled manner |   |   |
| 9) Demonstrates understanding of the importance of maintaining an aseptic environment when performing invasive procedures |   |   |
| Comments |   |   |

**Declarations**

*The author has declared that there are no conflicts of interest.*

*This has been published under Creative Commons "CC BY 4.0" ([https://creativecommons.org/licenses/by-sa/4.0/](https://creativecommons.org/licenses/by-sa/4.0/))