Review

Sounding out the future of ultrasound education

J Bowra[1,2], M Dawson[3], A Goudie[4,5] and M Mallin[6,7]

[1]University of Sydney, Australia
[2]Emergency Care, Sydney Adventist and Royal North Shore Hospital Hospitals, Sydney, Australia
[3]University of Kentucky, USA
[4]Emergency Department, Fremantle Hospital, Australia
[5]University of Western Australia, Australia
[6]University of Utah, USA
[7]Emergency Department, Salt Lake City Hospital, USA
Corresponding author: Justin Bowra. Email: justin.bowra@sah.org.au

Abstract

As in so many other fields, the internet has revolutionised medical education. It has done this by circumventing the traditional constraints of medical education, in particular the availability of local resources such as teachers and textbooks. This ''education revolution'' has been most successful in the areas of theoretical knowledge. This article explores the available resources, and the challenges that arise when attempting to teach point-of-care ultrasound via the internet, such as the visuomotor and visuospatial skills required to create a diagnostic image. This article also describes the progress to date in this field.

Keywords: Education, developing countries, emergency medicine, internet, clinician ultrasound, point-of-care ultrasound

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Introduction

As in so many other fields, the internet has revolutionised medical education. It has done this by circumventing the traditional constraints of medical education, in particular the availability of local resources such as teachers and textbooks. In medical education, this ''education revolution'' has been most successful in the areas of theoretical knowledge. This article explores the progress of internet-based education in the realm of clinician-performed ultrasound (US).

Point-of-care US

Clinician-performed US is also known as focused US, bedside US and more commonly as ''point-of-care US'' (PoCUS). PoCUS has many differences from consultative, comprehensive US imaging, whereby a clinician requests an US scan, which is performed either by a sonographer or radiologist (usually covering a broad anatomical region), then interpreted by a sonographer or radiologist (practice varies between different countries) and a report is created for the clinician to act upon. Perhaps the most obvious difference is that the same clinician performs, interprets and acts on the PoCUS scan during a single interaction. Another difference is that the clinician performing the scan may have limited training in US, and performs the scan in constrained circumstances (for example with limited time and in non-fasted patients). In addition (and sometimes partly due to these issues), the scan will often be performed to address only a single or small number of specific clinical questions, rather than a detailed and thorough examination of an anatomical region.[1]

The rapid expansion of PoCUS in recent decades can be traced to many factors, such as the availability of cheaper, portable machines, as well as practical limitations to comprehensive US (such as lack of after-hours availability). PoCUS is also supported by a growing body of research.[2–5]

Internet-based training

As a result of the relative novelty of PoCUS, clinicians who wish to learn and perform such studies face significant challenges, notably lack of opportunity to learn their craft from suitably trained teachers and mentors. However, with an US machine and access to the internet, clinicians can deliver cutting-edge medical care to their patients. This may help explain the attraction of internet-based education in PoCUS. For all its recency, traditional sources of teaching certainly exist for PoCUS (such as textbooks, university courses and hospital-based fellowships and special skills programs, which are essentially apprenticeships in PoCUS).

But compared to these, internet-based learning has the following advantages:

- Cost: for the learner, this may be little or none. In fact, much of the available e-content is free.[6]
- Online teachers: in a new field such as clinician US, local teachers are few and far between.
- Learning US while still undertaking their usual professional role: flexibility in timing means that the learner does not have to travel or stop practising their usual job (for example to perform a hospital-based fellowship).
- Availability: these resources are available to anyone with an internet connection.

As a result, there is a myriad of websites, blogs and smartphone applications that provide online education in clinician US. Examples can be found in the Appendix to this article.

Challenges

However, there remain significant challenges in the provision of PoCUS training via the internet.

The first challenge is the sheer complexity of performing and interpreting an US scan. Surprisingly little agreement exists on how complex skills, such as the use of US in clinical practice, are in fact learned. Theoretical constructs, particularly from the field of andragogy (the theory of adult learning)[7] are frequently applied to help explain how the process takes place. However, the pedagogy of e-learning itself also covers a large number of approaches and theories, and this inevitably adds further complexity when attempting to describe the process of US education.[8]

Despite this theoretical uncertainty, many teaching programs divide the required skill set into three components: (a) the physical skill of obtaining diagnostic images, (b) the interpretation of images and (c) the application of the diagnostic information to clinical problems. Each of these tasks is underpinned by background factual knowledge (such as the physics of US, anatomy, pathology etc), which can be provided using the tools of e-learning and the approach of the ''flipped classroom.''[9,10] Discussion of this factual knowledge then facilitates higher-order cognitive activities such as reasoning and application to actual patient care.

A second challenge is that of learning the psychomotor skills required for competent US practice. It may be that this presents the greatest single challenge for PoCUS teaching programs delivered via e-Learning. These skills include visuomotor and visuospatial skills in order to create a diagnostic image that is sufficiently near to a visual exemplar to be acceptable. Unlike ''closed'' skills which are relatively uniform and invariable (such as hitting a golf ball into a cup), these psychomotor skills are described as ''open'', because there are variations each time the skill is performed (e.g. different patient body habitus, acoustic windows etc. mean the task is not identical each time).[11] Simulators, whilst being able to assist in the skill development, therefore cannot substitute for actual experience. They have, however, been shown to be useful in the learning of similar complex procedural tasks.[12]

In fact, even within US education, some of the aforementioned skills have been effectively taught. Interpretation of US images from EFAST (extended focused assessment with sonography in trauma) were shown to be taught as easily via the web as in a classroom-based program.[13] Even skills such as vascular access have been shown to be taught on the web as effectively as through didactics.[14] Clearly, some of the skills necessary to be able to effectively use US at the bedside can be taught via the internet. It is not yet clearly defined, however, just how much of that skillset can be taught without personal contact and instead using real-time video conferencing tools such as Google Glass, Facetime, or Google Hangout.[15]

A third challenge for online content is that of quality control. The only practical bar to publishing content online is a lack of time and enthusiasm. Critics of online education have often pointed to the lack of peer review in the field, compared to the more rigorous processes employed by traditional journals and textbooks. In response, it may be noted that traditional textbooks are not peer-reviewed and therefore may be open to the same criticism levelled at their electronic counterparts. Furthermore, online resources such as Wikipedia have been somewhat validated. In a 2005 article in *Nature*, Wikipedia was found to be as accurate as the Encyclopedia Britannica.[16] Whilst it is true that Wikipedia is crowd-sourced with an extremely large base of contributors (unlike most online POCUS content providers), individual articles within Wikipedia frequently do have small numbers of contributors. Supporters of online educational material often quote ''crowd-sourcing'' through reviewer comments on blogs and podcasts. While this feedback could be considered peer-review, it occurs post-publication, as opposed to pre-publication as is seen in traditional educational means.[17]

There are also very practical challenges, such as

- Internet access: for example some hospitals maintain internet ''firewalls'' to restrict the use of social media by staff. However, this often has an unintended effect of preventing access to educational sites;
- Bandwidth requirements for multimedia-rich resources (e.g. video rich websites and videoconferencing);
- Intermittent contact between learners and teachers. Most distance-learning experiences still have limited contact time compared to traditional ''apprenticeship'' models of skill training. There may be variable access to teachers for immediate feedback for more complex cases or tasks, although availability via the internet or mobile telephone can reduce this problem;
- Less information available to teachers, particularly of motor skills. Depending on the arrangement, the teacher may only be provided with the final still images or may have access to a richer information stream,

such as real-time video feed of both the US image and patient / scanner, but there will always be less information available compared to a directly supervised teaching session. More information may assist in faster learning, particularly during early stages of learning the complex motor skills;

- The ability to store images from the US machine: traditional radiology information systems employed by radiology departments typically are designed for machines that are stationary, and employ patient data entry by clerical staff. By contrast, the portability of machines employed for PoCUS, and the often very limited time frame for data entry, limits clinicians' ability to transfer images for quality control and educational purposes;
- The cost of new US equipment: although the cost of US machines has fallen steadily in real terms, and new pocket-sized machines are becoming available, their cost remains high compared to that of other point-of-care devices. For example, even the most expensive pulse oximeters in the UK retail for less than 2000 GBP[18] while even the cheapest cart-based US machines cost more than 7000 GBP.[19]

A final, often overlooked challenge is that of sustainability. Many of the applications and internet-based content providers rely on the enthusiasm of individual clinicians and sonographers committing their spare time to the worthy goal of improved patient care, and no-one knows how sustainable this will be as a long-term model.

Overcoming the challenges

Attempts have been made to address these challenges. For example, several interactive online platforms exist that allow users to access didactic learning and assessment. For example, the website of the Australasian Society for US in Medicine allows members to log in and be assessed on their knowledge of US theory (physics and instrumentation) and access online educational content.[20] The Royal College of Radiologists and e-Learning for Healthcare UK have created an extensive e-learning resource for radiology trainees which includes US.[21] The American College of Emergency Physicians has also been involved in US education through its sponsored US education website Sonoguide (http://www.sonoguide.com) and an interactive bank of online questions (http://www.emsono.com/acep/exam.html).[22,23]

Other sites are international collaborations. For example, SonoWorld is a not-for-profit website founded in 1999 with the stated aim of providing "free educational materials to US practitioners in developing countries around the world."[24] The site allows users to access hundreds of lectures for free, although users who wish to undergo online tests for continuing medical education (CME) must pay a small fee (approximately 20 USD per CME credit at the time of writing).

US manufacturers often sponsor free online resources such as *Ultrasoundcases.info*, a web-based collaboration between Hitachi Medical Systems Europe and the Radiology Department of the Gelderse Vallei Hospital in Ede in the Netherlands. This site offers scanning protocols, still images and cineloops of deidentified cases, and allows users to test their ability to interpret images.[25] Some US manufacturers provide their own educational sites. In the field of PoCUS, SonoSite Pty Ltd is a leader in this field with a dedicated web page[26] and Youtube channel.[27]

Other content providers have addressed the above challenges by other means. For example, the Ultrasound Leadership Academy (ULA) is an non-profit online educational course that starts with a base of online content, supplemented by regularly scheduled online teleconferences, wherein students are mentored by US clinician experts who answer their questions and review the quality of their US images for quality of acquisition, interpretation and integration into clinical care.[28] Simulation is also incorporated with a proprietary US simulator which teaches US acquisition and interpretation.

Perhaps the greatest challenge is that of assessing users' image acquisition skills (rather than diagnostic skills) online. Different providers have attempted various methods of overcoming this. The ULA encourages students to review their images during one:one sessions with a supervisor using Google Hangouts, and even to scan under-supervision during these sessions. Students periodically attend conferences organized by the trainers so they are able to be assessed live with models. Other sites also allow users to upload their images for review by a remote assessor, such as the now-defunct *Ultrasound Training for Emergency Clinicians* (UTEC) program in Australia[29] and "The Emergency Ultrasound Course", delivered by 3rd Rock Ultrasound LLC in the USA.[30]

Studies have demonstrated the feasibility of US in remote environments such as the International Space Station, using a combination of introductory training for the crew, supported by real-time remote guidance by ground-based experts.[31,32] Therefore, geographical remoteness should no longer be a bar to education and performance of PoCUS. With simple, off-the-shelf social media applications and appropriately positioned cameras, an instructor can teach and assess a student from the other side of the globe.

Conclusion

Online education and assessment in PoCUS is not only possible it is also practical. It may also be the most practical, cost-effective way of educating the clinicians who need it most: those who practise far from the resources taken for granted by those of us who practise in large, well-funded teaching hospitals.[33] There are still issues with regard to its implementation, and these will take time to resolve. It should be noted that technology evolves at a very fast pace, not only in computing but also in ultrasound. It is likely that the future of ultrasound education, and medical education more generally, will be very different from its present.

DECLARATIONS

Competing interests: JB is a member of the medical advisory board of Signostics Pty Ltd. JB and AG are both employed as professors by Ultrasound Leadership Academy, founded by MD and MM. AG is director of Ultrasound Village, which runs ultrasound training courses. MD is a co-founder and co-director of the non-profit Ultrasound Leadership Academy. MM is a co-founder and co-director of the non-profit Ultrasound Leadership Academy and is a faculty member of The Emergency Ultrasound Course.
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Appendix

Examples of electronic educational material in point-of-care ultrasound

Podcasts

Academy of Emergency Ultrasound (Society of Academic Emergency Medicine) http://vimeo.com/channels/aeus

The Ultrasound Podcast http://www.ultrasoundpodcast.com/

Blogs

The EDE Blog http://edeblog.com/

Meritus http://meritus.kopernika.pl/

The Sono Cave http://thesonocave.com/

Sonokids http://sonokids.wordpress.com/

Sonospot. *Topics in Bedside Ultrasound.* http://sonospot.com/

Websites

Australasian Society for Ultrasound in Medicine http://www.asum.com.au/

European Federation of Societies for Ultrasound in Medicine and Biology http://www.efsumb.org

Neuraxiom. *Ultrasound guided regional nerve blocks.* http://www.neuraxiom.com/

New York School of Regional Anesthesia http://www.nysora.com/

Sonoguide (American College of Emergency Physicians) http://sonoguide.com/

Sonoworld http://www.sonoworld.com

The Emergency Ultrasound Course http://www.emergencyultrasound.com/

Ultrasound Cases http://www.ultrasoundcases.info

Organized online courses

Ultrasound Leadership Academy http://www.ultrasoundleadershipacademy.com/

123 Sonography http://123sonography.com/

Online videos

Youtube SonoSite channel https://www.youtube.com/user/SonoSite

Youtube WINFOCUS channel https://www.youtube.com/user/winfocus4all

eBooks

Socransky S, Wiss R. *Essentials of point of care ultrasound.* The EDE 2 Course; 2014

Dawson M, Mallin M. *Introduction to bedside ultrasound: Volumes 1 & 2*. Emergency Ultrasound Solutions; 2012

Rempell J, et al. *Practical Ultrasound Series: Deep Venous Thrombosis,* American College of Emergency Physicians. *Trauma Ultrasound eBook.* 2013

Smartphone Apps

One Minute Ultrasound (The Ultrasound Podcast)

Echocalc (British Society of Echocardiographers)

Emergency Medicine Ultrasound (EM Apps)