

A futuristic vision of pocket ultrasound machines: watch this space

Abstract

Introduction: Australian medical ultrasound started in 1959 with the establishment of the Ultrasonics Institute. Since then the technology has advanced tremendously. We are now not only able to obtain clearer images on high specification ultrasound machines but also on pocket-sized ultrasound machines that are compact, lightweight and affordable.

Method: The following descriptive review will examine the indication for use of pocket ultrasound machines in different clinical settings as well as provide evidence of its image clarity and accuracy. Potentially eligible studies were sought primarily through searches of the electronic databases PubMed, Medline (1996-Present), Embase (1996-Present) and Cochrane Library.

Conclusion: Pocket ultrasound machines, with appropriate ultrasound knowledge and training, can be incorporated successfully in patient management. The addition of point-of-care ultrasound has been shown to improve management recommendations and outcomes.

Keywords: echocardiography, emergency medical services, handheld ultrasound, pocket ultrasound machine, pocket-size, prehospital ultrasound, ultrasound curriculum.

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Introduction

Australian medical ultrasound has come a long way since the establishment in 1959 of the Ultrasonics Institute within the Commonwealth Acoustic Laboratories. The Institute established the use of ultrasound in medical diagnosis with George Kossoff as Director.¹

As the machines' functions improve, so does the ability to obtain clearer images to aid in diagnosis and management, miniaturisation seems to be the next step. Pocket-size ultrasound machines (PUM) can be divided broadly into two categories – a stand-alone unit where the probe is attached to the pocket-size ultrasound device or having the power of diagnostic imaging on a smartphone or tablet with standard off the shelf hardware but specially designed probe with universal serial bus (USB) connection. In the market today, there are at least 4 PUMs, two of which are available in Australia. They generally have a phased array transducer with frequencies between 1.7–5 MHz and operate in B-mode, M-mode or pulsed wave.

These systems have a range of applications – abdominal, fetal, cardiac, musculoskeletal and vascular. Pocket ultrasound machines' obvious advantages are portability, affordability and use at the point of care either within a hospital or in the community to assist clinicians in their decision making. Training in ultrasound is needed prior to its use.

Indications for use Echocardiography

Several studies to date have examined the use of

pocket ultrasound in cardiac evaluation. Adding cardiovascular ultrasound examination to routine history and examination has substantially improved recommendations for management as well as detection of important cardiovascular pathology.^{2,3,4} Even in a dedicated cardiac unit, the addition of cardiovascular screening with PUM to history, examination, laboratory tests and goal-directed imaging procedures other than echocardiography enabled correction of the primary diagnosis in 16% of patients and in 55% of the patients, the screening process had important diagnostic influence.⁵

Breitkreutz R, *et al.* evaluated focused echocardiography in resuscitation management and developed an algorithm to incorporate ultrasound into advanced cardiac life support (ACLS). They concluded that in a time pressured situation it can provide immediate information and can answer specific questions about the patient's condition. Their paper also alluded to the fact that focused echocardiogram can be learned in an eight-hour course by a non-expert sonographer.⁶ It is important to note that even though focused echocardiography in the above paper is not performed by a PUM, studies on PUM diagnostic capabilities in echocardiography have shown good concordance to standard echocardiographic instruments.^{7,8}

In 2011, the European Association of Echocardiography produced a position statement on the use of pocket size imaging devices and also highlighted the educational needs of potential users other than expert cardiologists.⁹

Emergency medical services

The concept of an early focused assessment with sonography in trauma (FAST) is not new.^{10,11} Information obtained is crucial and provides the clinicians with a tool to triage their patients more effectively. In some situations it can be lifesaving. A handheld ultrasound was put to the test following an earthquake that struck Haiti in 2010. The New Mexico Disaster Medical Assistance Team tested the machine's usefulness and concluded that ultrasound influenced decisions on patient care in 70% of scans.¹² It is also an ideal clinical tool in the battlefield especially with the constraints such as an austere environment demand.¹³

At the Vancouver 2010 Winter Olympic and Paralympic Games, having a PUM with ease of access, lightweight and high quality images was extremely useful in a confined space. Management plans for the athletes were made prior to the availability of a larger more sophisticated machine.¹⁴

Another important component of Emergency Medical Services is prehospital care. Walcher, *et al.* performed a prospective, multicentre study from December 2002 to December 2003 to compare the accuracy of physical examination and prehospital focused abdominal sonography for trauma (PFAST) to detect abdominal bleeding. Not only was PFAST more specific and accurate it also occurred 35 minutes earlier than ultrasound in the Emergency Department.¹⁵ In the Australian setting, a feasibility study by retrieval physicians at the Royal Adelaide Hospital concluded that it is possible even in a rotary wing aircraft to obtain adequate FAST images on patients but highlighted the fact that the physicians who performed the scans all use ultrasound in their daily clinical practice.¹⁶ Having the technology in prehospital settings could potentially avoid harm to patient from misdiagnosis.¹⁷

The palliative care unit at Ipswich Hospital and Ipswich Hospice located 40 kilometres west of Brisbane, Queensland acquired a PUM to expand its outreach service so that their patients can be effectively treated at home or in the hospice for acute events. This enabled the palliative care team to operate independently of the X-ray Department as well as avoid time and cost involved in a hospital admission. Since the addition of the PUM, only 1 in 10 of their patients still proceeds to a formal ultrasound.¹⁸

The speed and accuracy of diagnosis obtained by handheld portable ultrasound devices coupled with current ability to wirelessly transmit images with accuracy and clarity further improves patient care as a multidisciplinary team of clinicians can be consulted or be on site and ready while a patient is en route.^{19,20}

Obstetrics and gynaecology

Triage patients in obstetrics and gynaecology is paramount as two lives, that of the mother and the fetus, need to be taken into consideration. Sayasneh A, *et al.* from October 2011–January 2014 carried out a prospective observational cohort study in their early pregnancy and gynaecological ultrasound unit. Their study showed good to very good agreement between pocket ultrasound machine and high specification ultrasound machine in determining final diagnosis in all three of their study groups. The study was limited to a small number of defined ultrasound variables where knowledge gained is clinically important and

likely to influence patient management.²¹

The usefulness of point of care ultrasound in the out of hospital environment is shown in a case report by Byhahn C, *et al.* Diagnosis of cardiac tamponade following a cardiac arrest secondary to a stab assault enabled immediate lifesaving pericardiocentesis to be performed.²²

Wellbeing of a fetus in utero is important in clinical situations such as antepartum haemorrhage, abdominal trauma, preterm labour and preterm rupture of membranes especially in a rural and resource poor setting. Being able to use a pocket ultrasound machine for routine obstetrics examination will help triage patients in terms of transfer and mode of transfer to a tertiary unit for maternal or fetal reasons. This will also alleviate the strain already present in our current system. Galjaard S, *et al.* performed an observational cohort study and found perfect agreement for fetal position, fetal bladder and stomach. There was very good agreement on biparietal diameter and good agreement for femur length and transcerebellar diameter.²³

A common reason for transfer to a tertiary referral centre is preterm delivery. Identifying women at increased risk of preterm birth will potentially improve the outcome of these women and their babies. Two point-of-care tests, cervicovaginal fetal fibronectin and transvaginal sonographic cervical length measurement are clinically useful factors in predicting preterm birth.²⁴ Patient acceptability of a transvaginal ultrasound can occasionally impact clinicians' assessment of a clinical scenario if the woman refuses the examination. There is evidence to suggest that the cervix can be visualised adequately by translabial-transperineal sonography and measurements obtained are very similar to those obtained by transvaginal sonography.²⁵ A blinded study is currently underway in our centre comparing cervical length in pregnancy obtained with conventional transvaginal ultrasound versus transperineal ultrasound with a PUM.

A teaching tool

Medical students from the University of South Carolina School of Medicine were introduced to an integrated ultrasound curriculum across all four years of medical school. Their four years' experience concluded that ultrasound can be successfully incorporated into the curriculum, students can readily learn focused ultrasound examinations and it enhanced their medical education. Introducing PUM after the students established a solid foundation in ultrasound is however necessary.²⁶ In Gogalniceanu P, *et al.*'s study of Year 3 and 5 medical students, 85% of students without prior formal ultrasound training after a five-hour theoretical and practical FAST scanning course completed a full FAST scan at adequate level of performance in under six minutes.²⁷ Ross Brown in a special feature report said that the medical students and surgical residents they teach at the bedside with the added point of care imaging appreciate the benefits of the technology as it helped them correlate their knowledge with the clinical findings.¹⁴

Limitations

Despite the multiple benefits that this article has portrayed for PUMs, the performance of a machine is ultimately dependent on its users' experience in ultrasonography^{28,29,30,31} and ability to maximise the function of the machine.

Conclusions

Pocket ultrasound machines definitely have a great future in medical imaging as ultrasound technology continues to advance with better image quality and speed of data transmission. This imaging modality has the ability to provide crucial information with accuracy even in confined spaces. We can envisage its potential in bringing about a paradigm shift of huge proportions in patient management and teaching. It is probably the next revolution in medical imaging. More research is however, needed in the Australian setting with the available PUMs to identify its clinical impact and how it can be successfully incorporated into the different clinical scenarios, triage system and education setting. Structured training is necessary to maximise the potential of such technology.

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