Portable ultrasound on deployment

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PORTABLE ULTRASOUND became a viable diagnostic tool with the introduction of the SonoSite 180, developed for the US military. The SonoSite 180 was clinically evaluated for 12 months throughout 2000 at a major teaching hospital in Australia before deployment to United Nations Military (UNMIL) Hospital in Dili, East Timor. Two ultrasound units were available at UNMIL Hospital for 6 months from February to August in 2001. The units were used extensively for emergency and routine diagnostic scanning, and for training medical and other staff from many countries in the techniques of emergency scanning.[1] Deployment of the units further out in the field, and more extensive experience by some medical staff, proved their value. Sending a unit with a retrieval team also proved cost-effective. Since August 2001, tele-ultrasound has been used, with digital images sent by email from East Timor to Australia for expert diagnosis.

Abstract

Ultrasound for emergency medicine is a rapidly developing investigation, which provides more accurate triage of acutely ill or seriously injured patients. This was not possible until the development of truly portable high-resolution ultrasound scanners equipped with colour doppler facilities. Until that time, clinical assessment, together with procedures such as diagnostic peritoneal lavage, were used if a computed tomography scanner was not readily available. The delays inherent in such investigations, and the uncertainty about major or life-threatening injuries, has made portable ultrasound a valuable diagnostic tool.

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Stages of assessment of portable ultrasound

Introducing the clinical use of portable ultrasound required assessment of:

- available portable equipment, comparing its diagnostic ability with that of conventional machines, and assessing its ease of use
- the value of expert use in the field for military medical purposes and in the care of civilians in a peace-keeping setting
- medical and paramedical staff training programs within civilian and military organisations
- the value of trained non-experts using ultrasound equipment in the field
- the use of tele-ultrasound for expert diagnosis of ultrasound images.

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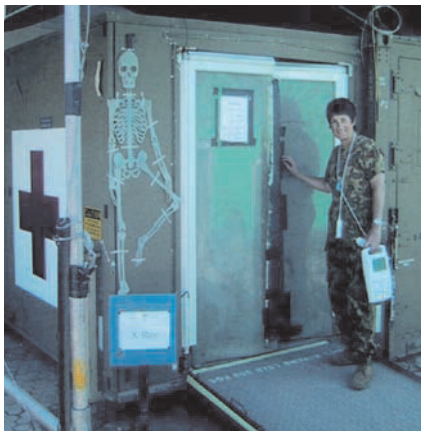
Portable equipment available

Until recently, so-called portable ultrasound machines were cumbersome and heavy, either on wheels or transportable on a trolley or wheelchair. They rarely had a colour doppler facility, and resolution, compared with the larger conventional machines, was significantly inferior. Colour doppler scanners represent movement within the body by rendering the doppler shift of the reflected ultrasound waves as a spectrum of colours (eg, red representing movement away from the ultrasound probe and blue representing movement towards the probe). Colour doppler imaging greatly enhances the diagnostic utility of ultrasound.

1: Imaging at UNMIL Hospital, February to August, 2001

Examination	Average per week	Range
X-ray		
Periphery	15	(10-25)
Chest	19	(9-55)
Abdomen	2.4	(0-5)
Skull	3.2	(1-7)
Pelvis	< 1	(0-2)
Cervical spine	4	(1-8)
Thoracic/lumbar spine	4	(1-8)
Ultrasound	12	(2-27)



Portable ultrasound at the radiology department at UNMIL Hospital, Dili, East Timor.

The SonoSite 180 (and more recently the upgraded version SonoSite 180 Plus) was developed for the United States Military to strict specifications, by ATL Ultrasound Inc, and subsequently by the stand-alone company SonoSite Inc, Washington, USA. The specifications issued by the US Military stated that it was to be a field device, hand-held by soldiers or medics, producing high quality images which could be downloaded via satellite to physicians at base hospitals.

The final product was light, weighing only 2.4 kg with a transducer attached, and had an appropriate range of high quality transducers, including a general purpose probe for abdominal, obstetric and gynaecological uses, a high frequency probe for small parts, vascular and superficial scanning, and an intracavitary probe for gynaecologic, obstetric and urological use. All have power doppler available (power doppler depicts the amplitude of doppler signals rather than the frequency shift, allowing detection of a larger range of doppler shifts at the expense of directional and velocity information). It was also equipped with a padded backpack, suitable for transporting the machine by air or road, and for carrying in the field. It could hold all available transducers, the SonoSite unit, recharging transformer, and accessories such as coupling gel and intracavitary sheaths.

This was the first truly portable machine available on the market, with extended functionality, and, although it was initially intended only for military use, it quickly became popular with civilian doctors, due to its high resolution and portability. Its low cost compared with the larger machines also made it accessible to individual clinicians and various hospital departments, particularly in emergency, intensive care and obstetrics.

The SonoSite 180 became available in Australia in December 1999, and the first unit in Australia was delivered to the Royal Adelaide Hospital for research and training purposes. At that time it was considered unlikely to be competitive with the large and much more expensive units, but the aim was to assess its potential value in remote areas and its use as a teaching tool.

From January 2000, the SonoSite 180 machine was used extensively in the wards, operating theatres and intensive care at the Royal Adelaide Hospital. While it was initially part of a research project to evaluate the images relative to the larger conventional machines, it very quickly became apparent that for routine diagnosis the images were comparable. The comparative research project was therefore abandoned, and the unit was used extensively as an adjunct to the larger more fixed machines. Its portability dramatically increased the efficiency of the Ultrasound Department, as mobile examinations could be performed whenever required.

Expert use in the field

Following this extensive clinical use in a civilian setting, the SonoSite was deployed to UNMIL Hospital in Dili, East Timor with 3rd Health Support Battalion (3HSB). From the time of its arrival it became invaluable during resuscitation procedures and for assessing other injuries and illness in the UN staff and soldiers. As shown in Box 1, ultrasound examinations made up a reasonable proportion of the imaging requests to the Radiology Department at UNMIL Hospital, with an average of 12 per week.

The variety of ultrasound examinations performed at UNMIL Hospital are listed in Box 2. Not surprisingly, a large proportion were focused abdominal sonography for trauma (FAST) scans. The examinations were performed on the patients as soon as they had been transferred onto the resuscitation bed from the ambulance trolley, and within 30 seconds it was possible to report to the resuscitation surgeon/doctor the presence or absence of intraperitoneal, pleural or pericardial blood. This occurred during the primary assessment, as intravenous cannulas were being inserted, and before any other imaging.

Once a week, the ultrasound unit was transported to the Dili General Hospital, which was initially under the auspices of the Red Cross. While demonstrating the use of portable ultrasound and training the local staff, up to 25 patients per session were examined. There was a wide range of type and severity of diseases seen in the local population. The treatment of many patients was significantly modified due to diagnoses made using ultrasound (eg, renal and

peritoneal tuberculosis, disseminated testicular and other malignancies, intrauterine growth retardation).

On several occasions, the ultrasound machine was also transported to Suai on the south coast of East Timor to train the medical and nursing staff there, and on one occasion to scan a patient before deciding on retrieval to UNMIL Hospital in Dili. This demonstrated the cost-savings that can be made by transporting the unit to the patient, rather than having to move and return the patient.

Training programs available

Several training programs are available in major Australian teaching hospitals to train emergency and retrieval staff in portable ultrasound, but there is no national coordination. Of the major training societies and Colleges, such as the Australian Society for Ultrasound in Medicine (ASUM), the Royal Australian and New Zealand College of Radiologists (RANZCR), and the Royal Australasian College of Surgeons (RACS), which coordinates the Early Management of Severe Trauma (EMST) course, none has coordinated the training for civilian or military personnel, although the EMST course usually includes a section on FAST scanning, as a preferred option to diagnostic peritoneal lavage.[2-4]

For about four years before deployment of the SonoSite in 2001, an accredited course had been held on several occasions at the Royal Adelaide Hospital, instigated by the late Dr Marie Kuhn, then Director of Emergency Medicine. This involved considerable theoretical preparation before the course, a one day intensive course of theory and practical work, with normal volunteers and patients available for scanning. Following this course, all diagnostic scans performed by these trainees on consenting emergency patients were recorded in their entirety on videotape, and I reviewed them, reading them with minimal clinical information, and also criticising the scanning and recording technique. The results were then independently compared, and feedback was given to the participating staff. All results were also matched to available "gold standards", such as computed tomography, surgery and diagnostic ultrasound. The results of some of these studies have been published.[5]

Using the training materials developed for these courses, including lectures on compact disk covering physics and scanning techniques, and videotapes of representative cases, a 2–3 hour course covering the basics of theory and practical ultrasound was held regularly at UNMIL Hospital for 1 to 4 trainees. During the practical training the staff scanned each other. The number and nationality of the medical staff who underwent the course is listed in Box 3. A number of non-medical staff, including nurses, radiographers and medics, were also trained and were enthusiastic about their ability to produce diagnostic images with little training.

2: Types of ultrasound examination performed at UNMIL Hospital, February to August, 2001

FAST	43 (13%)
Abdomen	65 (20%)
Renal	75 (23%)
Obstetrics and gynaecology	32 (10%)
Small parts	
Musculoskeletal	*38*
Eye	*12*
Venous	*15*
Testis	*9*
Thyroid	*8*
Breast	*5*
Cardiac	*6*
Carotid	*4*
Head	*2*
Appendix	*2*
Total small parts	101 (31%)
Chest	10 (3%)

3: Number and nation of doctors given training courses in emergency ultrasound (UNMIL Hospital, February to August, 2001)

Australia	29
Singapore	5
Egypt	5
New Zealand	4
Portugal	2
Kenya	2
Bangladesh	2
Germany	1

Value of trained "non-expert" personnel in the field

The medical staff who undertook this course in East Timor were from many parts of the world, and all were quickly able to scan competently and diagnose absence of fluid in the relevant areas of the FAST scan. Many also had the opportunity to use the machine during resuscitation procedures, and were shown to be competent in emergency scanning.

Several Australian doctors were particularly enthusiastic about the equipment, and spent much of their spare time perfecting their scanning technique on various parts of the body. This was useful in venous line insertions and small parts scanning.

An ultrasound unit was also sent to Balibo, near the border with West Timor, and used extensively by one of the medical officers. This demonstrated not only the effectiveness of the course and the confidence in scanning that can be obtained from even a short period of instruction, but also the value of deploying the unit. Images recorded on the machine were available for reporting on its return to UNMIL Hospital.

Tele-ultrasound

During the deployment, teleradiology and tele-ultrasound were trialled, using both a landline and a portable phone to transmit images by email. Transmission times using the portable phone were very long, often 5 minutes per image, and the uncertain transmission and frequent drop-out of the signal meant that this system was unreliable. However, using the landline enabled rapid transmission of digital images of both x-rays and ultrasound scans for remote reporting.

Initially the ultrasound images were downloaded from the SonoSite 180 to a computer, then transmitted by email. X-rays for transmission were photographed using a digital camera, with closeups of areas of interest provided by using the macro option on the camera. Further trials demonstrated that the

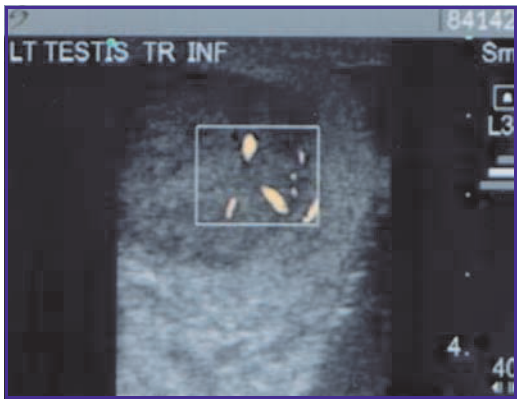
ultrasound images could also be recorded with adequate resolution using a digital camera aimed at the unit's screen, and this significantly shortened the time between obtaining the image and transmitting it for review.

After my return to Australia, the radiographers and doctors at UNMIL Hospital continued to email x-ray and ultrasound images for diagnosis, and both teleradiology and tele-ultrasound proved clinically useful and efficient. In one patient, a child from the Dili General Hospital, a grossly abnormal head ultrasound was referred to an Australian expert, again by email, and a likely diagnosis was obtained. However, a more formal method of transmitting and reporting these cases must be developed. Consideration must also be given to the need for formal reporting of all radiographs and ultrasound examinations performed in the field, preferably by a qualified radiologist, and the inclusion of the report in the ADF member's medical file.

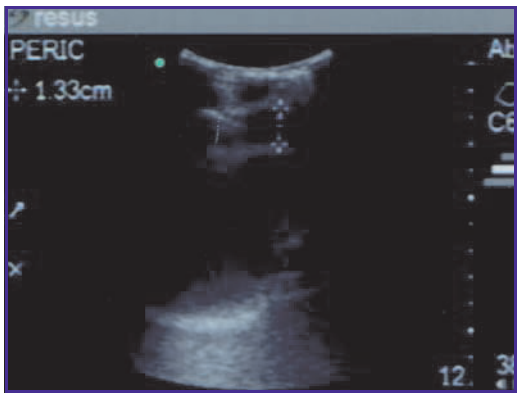
Controversies in portable ultrasound

The value of a trained sonologist (such as a radiologist) in the field has not yet been determined. Many of the doctors involved in resuscitation procedures were grateful for a trained person to provide rapid diagnoses concerning free intraperitoneal blood, and also to have rapid reports on the plain trauma films as they became available. In a military situation where there is a high trauma load, the presence of a radiologist would be invaluable. Where there is a large military population, or where the military is responsible for a large civilian population, the use of ultrasound is also very useful. Paediatric and obstetric patients require ultrasound as the investigation of choice, and a trained sonologist (radiologist, obstetrician or paediatrician trained in ultrasound) would be an asset. A radiologist trained in basic trauma medicine (eg, EMST) can also be of assistance clinically, and may be the most experienced at inserting venous lines under ultrasound control in difficult patients (eg, children, burns victims).

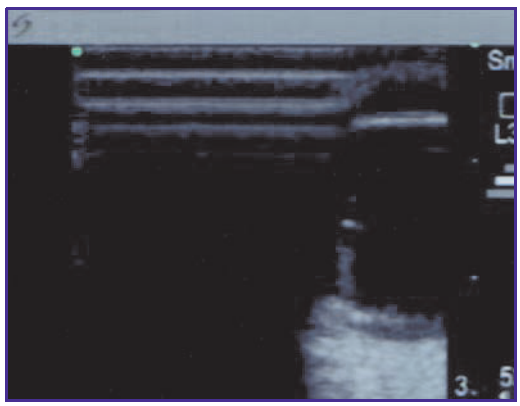
Recruitment of radiologists should be a priority, to aid in training the medical and paramedical staff who will deploy with portable ultrasound in the future. A critical mass of radiographers is also required to use the equipment and aid in training.



Testicular tumour diagnosed in patient undergoing antibiotic treatment for epididymo-orchitis. A 3 cm seminoma was treated with orchidectomy and chemotherapy.



Bloody pericardial tamponade, treated by needle aspiration, in a 55 year old female civilian, a victim of a hit-run accident.



Metallic foreign body in the eye of a New Zealand soldier, sustained while hammering a metal tent peg.

Conclusion

Portable ultrasound scanning using the SonoSite 180 (and 180 Plus) has proved extremely useful in civilian and military medical practice, and on deployment. Its resolution is adequate for emergency diagnosis during resuscitation procedures, and for routine scanning. It is particularly useful in situations where a computed tomography scanner is not readily available.

Provided that appropriate accreditation standards are maintained, the FAST scan can be readily taught to medical and paramedical personnel. With expansion of teleradiology facilities, digital ultrasound images will be transmitted from remote sites for expert diagnosis or for direction on emergency treatment.

A short training course has been developed and has proved adequate for training medical and paramedical staff in FAST scanning for emergency use. With more extensive practice by medical and radiographic staff, adequate routine diagnostic scans can be performed, and can be interpreted locally or transmitted by tele-ultrasound for expert consultation. Sending a unit with a resuscitation team is cost-effective, as it can modify or negate the need for retrieval, or change the patient's treatment before or during transport.

Competing interests

I received no financial support from and have no financial interest in SonoSite Incorporated or any other manufacturer of ultrasound equipment.

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