BRIEF REPORT

Change in Differential Diagnosis and Patient Management With the Use of Portable Ultrasound in a Remote Setting

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Objective.—Physicians practicing in remote areas are typically limited in their choice of diagnostic tools. The goal of this study was to determine whether the use of a portable ultrasound (US) device on selected patients in a remote setting would alter physician diagnosis and management.

Methods.—This was a prospective observational study of the affects of US on physician decision making deep in the Amazon jungle. A battery-operated Sonosite 180 Plus with 2 interchangeable transducers (4–7-MHz broadband intercavitary transducer and 2–5-MHz broadband abdominal transducer) was used. The patient population consisted of local tribal people. Two of the physicians on the team performed all US examinations. Team physicians requesting US examinations filled out a survey before and after the US examination. Before the US, the referring physician filled out a survey describing the patient's initial complaint, pertinent past medical history and physical findings, and an initial (pre-US) differential diagnosis and planned treatment with expected disposition. After the results of the US were reviewed with the referring physicians, the doctors were asked to fill out the remainder of the survey, allowing comparison of pre- and post-US differential diagnosis, treatment plan, and disposition.

Results.—A total of 25 US studies were performed during this study (1 trauma US scan, 6 hepatobiliary studies, 5 transabdominal pelvic scans, 7 transvaginal pelvic studies, 3 renal studies, and 3 abdominal aortic scans). The monitor on the US unit experienced a rare failure shortly after being used at 17,000 ft and then 10 times at sea level, and no further US scans could be performed. US scan results dramatically altered the disposition of 7 patients, including 4 patients who avoided a potentially dangerous 2-day evacuation to more definitive medical care. Three patients were found to need rapid referral to the nearest clinic for surgical evaluation.

Conclusions.—When used in a remote location, portable US provides a significant benefit that can dramatically alter disposition and treatment.

Key words: emergency ultrasound, portable ultrasound, remote setting, emergency medicine, ultrasound, rural medicine

Introduction

Delivery of care in a remote setting brings with it many challenges. Whether medical attention is required on a mountain top, on the battlefield, or in the jungle, one of the common limiting factors is lack of diagnostic equipment. For most hospital-based physicians, it is difficult

to imagine evaluating an ill patient without the aid of imaging equipment such as plain radiography and computed tomography. However, patients seen in remote locations can be just as sick as those arriving at the trauma centers and intensive care units of tertiary care hospitals.

To date, little has been available in the way of portable diagnostic equipment short of limited, battery-powered, blood-analyzing equipment and microscopes. Until recently, ultrasound (US) was considered potentially mobile, but with most units weighing over 300 pounds, a machine could not venture far off the paved road. Development of handheld US machines has allowed this

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A patient in the remote clinic is being scanned using the Sonosite 180 Plus. He had fallen from a tall tree and was complaining of abdominal pain. A decision about air evacuation to a permanent clinic with surgical capability was being made.

modality to be placed at the point of care even in the most remote regions in the world. Concomitantly, US researchers have explored an increasing number of applications for the evaluation of potentially critically ill patients at their “bedside.” Such applications are well suited for medical patients as well as trauma victims in the wilderness and remote areas.^{1–4} We studied the effect of portable US in the evaluation of patients seen at a temporary jungle medical clinic in the Amazon.

Methods

This was a prospective survey of physicians ordering US examinations during two visits to remote Amazon Indian settlements to provide temporary medical care. Patients presenting to one of two temporary, remote medical clinics in the Amazon jungle were evaluated by physicians providing volunteer medical care. The patient population consisted of Nomatzieguenga and Ashaninca tribal people, who are normally cared for by the local tribal doctor and whom Western physicians otherwise do not encounter in this area. No modern medical equipment is available to the native peoples. US use for evaluation of abdominal, pelvic, and chest problems is routine on our medical mission trips. At least 20 such missions have involved US utilization. In all cases, equipment was donated by Sonosite for the length of the mission.

A battery-operated Sonosite 180 Plus (Bothell, Washington) with 2 interchangeable transducers (a 4–7-MHz broadband intercavitary transducer and a 2–5-MHz broadband abdominal transducer) was transported to a remote field clinic deep in the Amazon jungle. The US unit was operated by multiple backup batteries, as no electricity was available for recharging. Two of the physicians on the team performed US examinations (see the Figure). Both physicians received emergency US training at the Medical College of Georgia Department of Emergency Medicine. Physicians (members of the mission) requesting US examinations filled out a survey before and after the US examination. Before the US, the referring physician described the patient’s initial complaint, pertinent past medical history and physical findings, an initial (pre-US) differential diagnosis, certainty in the diagnosis, and planned treatment with expected disposition. After the results of the US were reviewed, the referring physician was asked to fill out the remainder of the survey, allowing comparison of pre- and post-US differential diagnosis, treatment plan, and disposition. US performance by the team is standard practice on these missions. Descriptive statistics were used to analyze the data. Data were analyzed using statistical calculators from a commercially available software package, StatsDirect (Cheshire, United Kingdom).

Alteration of disposition plans based on field ultrasound results in 7 patients*

<i>Patient</i>	<i>Pre-US DDX</i>	<i>US study performed</i>	<i>Post-US DDX</i>	<i>Altered disposition</i>
1	Hemoperitoneum, musculoskeletal pain	FAST	Musculoskeletal pain	Avoided emergent evacuation to clinic
2	Ectopic pregnancy, intrauterine pregnancy, failed pregnancy	Endovaginal	Intrauterine pregnancy	Avoided evacuation for emergent obstetric evaluation for pain and bleeding
3	Renal mass, renal stone, muscular flank pain	Renal scan	Flank pain	Avoided emergent referral for renal mass evaluation
4	Parasitic liver cyst(s), gallbladder stone, hepatomegaly, nonspecific pain	Liver	Nonspecific pain	Avoided emergency referral to clinic for liver parasite
5	Abdominal aortic aneurysm, abdominal mass, constipation	Abdominal	Abdominal mass	Referral for abdominal mass evaluation
6	Pelvic infection, ovarian cyst, pelvic mass	Abdominal	Pelvic mass	Referral for pelvic mass evaluation
7	Pelvic infection, ovarian cyst, pelvic mass	Endovaginal	Pelvic mass	Referral for pelvic mass evaluation

*US, ultrasound; DDX, differential diagnosis; FAST, focused abdominal sonography for trauma.

Results

A total of 25 patients were scanned with US. Studies performed included 1 trauma US scan, 6 hepatobiliary studies, 5 transabdominal pelvic scans, 7 transvaginal pelvic studies, 3 renal scans, and 3 abdominal aortic examinations. The consulting physician's differential diagnosis narrowed after US examination in 72% of cases. The certainty of the diagnosis improved in 17 out of 25 patients (68%) after US performance. The consulting physician's diagnostic certainty remained the same in 6 out of 25 patients (24%) after US examination and actually decreased in 2 (8%) patients in whom the supposed pathology was disproved on US.

Data were collected over two remote medical field clinic trips to the Amazon jungle, each lasting approximately 2 weeks. A total of 800 patients were seen, most for minor complaints. However, the LCD monitor on the US unit experienced a rare failure shortly after being used at 17,000 ft and then 10 times at sea level, and no further US scans could be performed on the first trip. The team has used similar US machines at altitude before with no failures. Results of the trauma US scan and abdominal and transvaginal pelvic studies drastically altered the disposition of 7 patients (see the Table).

Discussion

Medical care in a remote setting has always been challenging and has often compared poorly to that available in the urban setting of the Western world. In recent

times, portable blood analyzers and urine dipsticks have made some testing possible for an expedition capable of carrying extra weight. However, imaging has for the most part been impossible in most remote settings. One of the few imaging modalities that could be available in the wilderness is US. Although early US machines weighed hundreds of pounds, some now weigh in at less than 6 pounds and give images comparable to their larger cousins.⁵

US has a number of applications for ill and injured patients. Although traditionally used to diagnose gallstones, abdominal aortic aneurysms, pregnancy, and cardiac dysfunction there are additional applications that may be especially useful in a remote setting. Many of these have something to do with trauma, either blunt or penetrating. These include the ability to diagnose or rule out intraperitoneal fluid, hemothorax, pericardial effusion, fractures, elevated intracranial pressure, diaphragmatic rupture, and pneumothorax, as well as enabling visualization of blood vessels to aid in obtaining vascular access.^{2-4,6-9}

The list above includes many disease states that could require immediate correction, such as a large pneumothorax or pericardial effusion (with possible tamponade). It also includes pathologic states that would necessitate immediate evacuation to a higher level of care, such as in the discovery of intraabdominal fluid in a mountain climber who has fallen. One of the most important capabilities provided to the medical team in the remote setting by portable US is the ability to triage patients

based on actual imaging findings. This may be especially critical when evacuation by air, although possible and faster than by foot, may be extremely dangerous or expensive. Similarly, if multiple casualties are present, decisions may need to be made regarding which patients require priority evacuation.¹⁰

US has already proven its worth for triaging multiple trauma patients in a mass casualty setting. During the Armenian earthquake of 1988, physicians with two US machines were able to triage nearly 400 blunt trauma patients in 48 hours.¹¹ Decisions were made, based on trauma US results, regarding observation and admission to the hospital, intensive care unit, or operating room. In our study, we did not triage multiple trauma patients, nor were we at a disaster scene. The utility of US was clear nonetheless. Evacuation was possible either by foot (2 days) or by air followed by driving; both methods were dangerous. The air evacuation option was expensive and potentially dangerous with tropical weather. The physicians obtaining US examinations in this study found the main benefit to be an increased certainty about their diagnosis and narrowed differential diagnosis. Simply narrowing the differential diagnosis resulted in a direct benefit, as treatment using scarce resources could be more focused. However, in 28% of cases, lengthy transfer to the nearest clinic was avoided, as pathology was ruled out at the patient's "bedside." These changes in management included US-directed conservative management of a blunt trauma patient rather than transfer out of the jungle. Similarly, avoiding transfer to a distant clinic for evaluation and treatment of suspected gallstones and ectopic pregnancy yielded a considerable savings in resources. The results obtained in this study support the use of portable US technology in any setting in which medical care is not readily available and patient transfer may be limited, dangerous, or impossible.

On one of two medical missions included in this study, the Sonosite US machine failed. This is the first such failure out of over a dozen such trips by our department, several of which encountered similar environmental conditions. After the failure was analyzed by the manufacturer, it was determined that a flexible connection between the US screen and the rest of the machine failed. According to Sonosite, this failure is seen in approximately 1 out of 1000 US machines. Anecdotally, we have not heard of other failures on trips ranging from medical missions to disaster relief and military expeditions.

This study had several limitations. It was of a prospective observational design using a survey and did not compare different groups. Only two physicians out of

the entire team performed US examinations. The sample size was small. However, it is likely that the technology's utility would still be the same in the setting of a larger population. The range of pathology scanned may vary from setting to setting, however, and evacuation distances and referral patterns may vary widely from what was encountered here.

In summary, when used in a remote location, portable US provides a significant benefit that can drastically alter the disposition and treatment in patients who might otherwise require evacuation over considerable distances, at high cost, and through potentially dangerous terrain.

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