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Pocket-size point-of-care ultrasound in rural Uganda — A unique opportunity "to see", where no imaging facilities are available

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ABSTRACT

Background: In the developing world, only a small minority of patients have access to radiological services. Over the past decade, technological developments of ultrasound equipment have led to the emergence of point-of-care ultrasonography (POCUS), which is widely used by healthcare professionals of nearly all specialties. We hypothesized that physicians with only basic POCUS training, but with telemedicine support, can use POCUS successfully in rural hospitals in sub-Saharan Africa.

Method: During a 14-day voluntary clinical work session in a rural hospital in central Uganda, bedside ultrasound scans were performed by use of a pocket-size portable machine by a physician who underwent a five-day training period. All the POCUS studies were reviewed by radiologists and cardiologists abroad with the use of telemedicine.

Results: During the study period, 30% of patients received a POCUS-augmented physical examination. 16 out of 23 patients (70%) had positive findings; in 20 of them (87%), the management was changed. The technique was successfully used on trauma casualties, patients suffering from shock, patients with cardiorespiratory symptoms, and patients undergoing invasive procedures.

Conclusions: In a very resource-limited environment, POCUS conducted by basically trained primary care physicians with telemedicine support is a powerful diagnostic tool in a variety of medical conditions.

1. Introduction

The field of medical imaging, stimulated by advances in digital and communication technologies, has revolutionized almost every aspect of medicine over the last decades. This revolution, however, has taken place almost exclusively in medium and high-income countries.

However, over 80% of the world's population live on less than 10$ (USD) per day and as much as 47% of Africa's population lives on 1$ or less a day [1,2]. Many rural hospitals in the developing world have no reliable water and electricity supply [3]. As many as fourteen African countries have no radiologists at all, and most have fewer than thirty, with only five residency programs for radiology on average [3,4]. The lack of water and electricity, and of human resources often goes with a general lack of public infrastructure, such as roads and railway links. As a result, only 220 million people in the developing world (out of more than five billion) have access to basic radiology services, such as X-rays [3].

Over the past decades, ultrasound equipment has become more compact, portable, of higher quality, and less expensive. This has led to the emergence of point-of-care ultrasonography (POCUS), that is, ultrasonography brought to the patient and performed by the treating clinician in real time, allowing findings to be directly correlated with the patient's signs and symptoms [5].

Nowadays, smartphone-size machines retails for less than 10,000$ have dual probes with low- and high-sound wave frequencies, allowing the operator to observe superficial (vascular, soft tissue) as well as deep

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(cardiac, abdomen) anatomical structures, augmented by color Doppler capabilities [6]. Some machines even include M-mode capabilities [7].

In high-income countries, this diagnostic modality is utilized by healthcare professionals of nearly all specialties [5]. Many medical schools have integrated POCUS into their teaching curriculum [5]. Studies have shown that physicians and others can be expected to perform effective and accurate scans after as little as 3 h of didactic training and 5 h of hands-on training [8,9].

The advantages of ultrasound in resource limited environment are well established. In 1985 the World Health Organization (WHO) concluded that there are “very real advantages to be gained from the use” of ultrasound, and noted its potential for ”improved patient management and care of the individual” in developing areas [10]. A recently published, systematic review of the use of portable ultrasound devices in low- and middle-income countries found 36 published articles [7]. However, all but one study were performed in large hospitals with a relatively wide variety of facilities and the help of an experienced sonographer.

POCUS, performed with portable devices, was successfully used by sonographers and cardiologists in low- and middle-income countries in a variety of medical conditions. Kobal et al. successfully evaluated 126 patients referred for cardiac evaluation in rural Mexico [11]. Few studies demonstrated the successful use of hand-held ultrasound to screen for rheumatic heart disease, reduced ejection fraction, valvular regurgitation, wall motion abnormalities and presence of pericardial effusion. Various ultrasonographic protocols were developed for risk stratification of patients with malaria, filariasis and dengue in the developing world [7]. In India and Thailand POCUS was successfully used to confirm the position of an endotracheal tube and assess laryngeal edema before extubation [12,13]. Hand-held ultrasound devices were successfully used by aid teams to perform modified FAST examinations in 2010 earthquake in Haiti. The authors reported that ultrasound examination findings changed the clinical management in 70% of patients evaluated [14]. Similar findings were reported by in Guatemala and China [7]. POCUS was reported to be useful for diagnosis of intussusception, evaluation of soft tissue masses, breast masses and various gynecological conditions [7].

In this article we describe our experience, and review the potential applications of a pocketsize, portable ultrasound scan with telemedicine support in a rural hospital in Uganda.

2. Material and methods

Kiboga hospital is a governmental general hospital with 210 beds. It is located 3 h' drive on rugged road northwest of Mulago National Referral Hospital, Kampala, Uganda. The Kiboga campus has no running water, very limited laboratory capabilities (complete blood count, blood smear microscopy, malaria and HIV rapid diagnostic tests, CD4 count and Gene Xpert machine), and has no imaging facilities. The hospital is understaffed, with only one local physician on call at any given moment. This hospital serves a population of more than 250,000.

All ultrasound scans were performed with a pocket-size, portable ultrasound machine (Vscan®, GE Healthcare, USA) with a single low-frequency probe (1.7–3.8 MHz). The studies were performed over a period of 14 days by an internal medicine resident, who was providing volunteer medical care as part of the Israeli Medicine on the Equator project. All studies were conducted for clinical indications.

Most of the physician's time during this period was spent on clinical work in the hospital and in outreach clinics. Prior to deployment, the resident underwent a five-daylong, formal POCUS course. The course's curriculum is described in Box 1. Course syllabus included: cardiac ultrasound anatomy with practical hands-on sessions, utilization of ultrasound to narrow differential diagnosis of shock, lung ultrasound, focused assessment with sonography for trauma (FAST) as well as hands-on sessions of ultrasound guided vascular access.

All the POCUS studies were reviewed by experienced radiologists and cardiologists abroad with the use of cellular phones, commercially available video-chat software, and a 3G cellular data network. Most studies were reviewed online and some within 3 h of the procedure. The radiologist was able to visualize both the ultrasound scan and the patient (Fig. 1). This simple method of telementored ultrasound screening was previously investigated in healthy volunteers and shown to be useful [9].

Ultrasound equipment was donated by Eldan-Life Science & Healthcare Solutions for the length of the mission.

Patients' data were recorded as part of medical history taking. All radiologic tests were performed as part of routine clinical work. An informed consent was therefore not required. There is no formal ethics committee in Kiboga hospital. Therefore, in concordance with ICMMJE recommendations [15], the data publication was discussed with institutional management and found to be in accordance with the Helsinki Declaration as revised in 2013. We believe that publication of data, collected during routine and voluntary clinical work, is in concordance with all international legal, ethical and regulatory norms and standards.

3. Results

Over a 14-day period, 23 of the 75 (30%) acutely ill patients received, by clinical indication, augmented physical examination using pocket size ultrasound machine. 16 of the 23 patients who received POCUS (70%) had positive ultrasonography findings and for 20 of them (87%) management was changed (in four patients, a previous clinical diagnosis was ruled out). These included three trauma patients, seven patients with cardiorespiratory symptoms, and four patients suffering from shock. Three patients were evaluated because of suspected hepatosplenomegaly, two had clinical suspicion of significant pleural effusion and two were confirmed to have urinary retention. The results of POCUS exams and their clinical implementations are summarized in Table 1. As mentioned previously, all the studies were reviewed by experienced radiologists and cardiologists, who were all in agreement with the treating physician.

3.1. Trauma

Focused Assessment with Sonography in Trauma (FAST) was performed on three patients. Two of them suffered blunt trauma, secondary to motor vehicle accidents, and one suffered penetrating abdominal stab wounds. Two of the three studies were positive, demonstrating a large amount of free intraperitoneal fluid (Fig. 1). Both patients were promptly referred to a tertiary hospital in Kampala after initiation of fluid resuscitation. They were diagnosed with high-grade splenic injuries; one of them was treated conservatively while the second patient underwent urgent splenectomy. The third patient had negative study and was discharged after observation.

3.2. Focused cardiac ultrasound

Echocardiographic studies were performed on seven patients with main symptoms of dyspnea, chest pain, and palpitations.

Severely reduced left ventricle ejection fraction (LVEF) was demonstrated in three patients with no previous history of congestive heart failure. One of these patients, a 40-year-old, previously healthy woman was diagnosed with atrial fibrillation, severe mitral regurgitation and significant mitral stenosis, most probably of rheumatic origin (Fig. 2). She was started on aspirin and beta-blockers (anticoagulation drugs were not available) and referred to a cardiologist in Kampala.

Large pericardial effusion without echocardiographic signs of tamponade was diagnosed in a previously healthy 24-year-old male with fever, cough, and chest pain (Fig. 3). Serial echocardiographic studies were performed. No fluid enlargement or signs of chamber wall collapse were recorded.