**World Journal of Health and Medicine**

**ISSN: 2584-0223**

**Research Article**

Volume 3, Issue 2

# Point-of-Care Ultrasonography for Remote Patient Assessment: Investigating the Usage of Portable Lung Ultrasonography for Rapid Evaluation and Diagnosis in Remote Settings

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Received Date: March 27, 2025; Accepted Date: May 02, 2025; Published Date: May 14, 2025

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**Citation:** Shehzad khan, SanyaHadi, Amin ullah shah, Hamza Danish, Asmahadi. Point-of-Care Ultrasonography for Remote Patient Assessment: Investigating the Usage of Portable Lung Ultrasonography for Rapid Evaluation and Diagnosis in Remote Settings. *W J Heal Med.* 2025;3(2):01-07.



## Abstract

It might be possible to employ Point-of-Care Ultrasonography (POCUS) accompanied by the patient in home healthcare. We looked into whether inexperienced consumers could attain similarly interpretable and high-quality Lung-Ultrasound (LUS) imageries by self, scanning as experienced users. Adult volunteers, who could view power-point slides at home, grip the probe to their chest and had no earlier therapeutic or point-of-care ultrasonography training remained sought out. Following training, volunteers used hand-held point-of-care ultrasonography devices in their own, homes to self-perform 8-zone LUS and save images. Point-of-Care Ultrasonography (POCUS) specialists repeated every 8-zoneslung-ultrasound scan. Point-of-care ultrasonography specialists who remained blinded to the performing sonographers independently watched and scored the clips. The quality and interpretability ratings of LUS images obtained by experts and novices were compared. We recruited thirty volunteers with a average age of 42.8 years (SD 15.8) and average body mass index of 23.7 (SD 3.1). The Inter Quartile Range (IQR) of the novice and expert scans (2.6 for the former and 2.8 for the latter, respectively; p = 0.09), showed no difference in quality. The quality of each individual zone did not vary either (P > 0.05). With little training, novices can get comprehensible and

professional grade lung-ultrasound scan clips on their own. It might be possible to use patient-performed LUS for outpatient home monitoring.

## Introduction

Since becoming more widely used in medicine in the 1960s, ultrasound has been used more and more for a range of diagnostic procedures. It is a valuable imaging modality. Although in the beginning it was primarily used for obstetric scans, its applications today span many areas of medicine. Ultrasound machines, including handheld / potrable models, are now more affordable, portable, and user-friendly thanks to recent technological advancements. Point-of-care ultrasonography has grown in popularity therefore result of technological advancement, especially in emergency medicine and in areas that are distant from general routine medical treatment [1]. Higher expenses for transportation, a rise in co-existing conditions and limited admittance to the healthcare amenities in the rural and isolated areas all contribute to rising healthcare costs [2]. In prehospital and primary care settings, POCUS is a crucial clinical-tool, especially for obstetrics and abdominal assessments. According to a study, more than 95% of the patient said Point-of-Care Ultrasonography (POCUS) had enhanced their main care visit, and about 45% said that there is a relationship between the patients and the provider should become better. No patients in the study reported a negative experience with the POCUS exam, which is a component of the physical assessment [3]. In health care settings and communities with limited resources, bedsides ultra-sound can too be utilized for the purpose of some other signs, such as cardio-pulmonary, tissues softening, and for assessment of muscle-skeletal [4].

Without sacrificing precision or safety, POCUS can identify cardiac problems like reduced systolic function and pericardial effusion. POCUS is a very sensitive diagnostic tool that improves interval to the diagnosis for conditions like heart failure. With the right provider education training, it can improve the deep vein thrombosis diagnostic accuracy [5]. Ultrasound/ Sonography are a useful instrument for detecting abnormalities happening in the lungs and for rapidly ruling out pleural fluid (effusion) or pneumonia (areas of consolidation). For respiratory and some cardiac processes, POCUS has a much higher sensitivity and specificity than chest X-rays [6]. POCUS can eliminate conditions like abdominal aortic aneurysms (AAA) in individuals who are not obese; reducing the duration of time patients must wait for official diagnosis. Furthermore, it has been discovered that POCUS for AAA screening has 93% sensitivity and 97% specificity, which is better than abdominal discomfort alone [5]. In obstetric and gynecologic care, ultrasound is acknowledged as a routine diagnostic procedure, particularly when used at the bedside. POCUS is a useful tool for evaluating and assessing intrauterine pregnancy as well as ruling out warning signs like stillbirth, ectopic pregnancy, and fetal complications. POCUS can also be used in the prenatal stage to determine the approximate gestational age, the number of fetuses, and any anomalies. Joint and soft-tissue injuries are among the many presenting complaints for which bedside ultrasound can improve diagnostic accuracy. Using ultrasonography may also enable visualized guidance when injecting corticosteroids into joints. POCUS lowers the rate of misdiagnosis by promoting accurate diagnosis of musculoskeletal complaints [7]. Testing for blood, urine, and imaging has been acknowledged as "essential" when dealing with acute abdomen [8]. A pocket probe is an ultrasonic probe that is easily accessible, easy to carry, inexpensive, and simple to operate. Instead of using piezoelectric crystals as they formerly did, manufacturers have adopted technological advancements to cut costs and complexity. Rather, a unique ultrasound-on-chip technology approach is employed, which combines 9,000 micro-sensors arranged in two dimensions, which can replicate phased-array, linear and curved transducers within the 1 MHz to 5 MHz frequency range. This innovative technology departs through the conventional crystals with the piezoelectric properties used in expensive image acquisition the probe that call for the

different probe for high and low frequency analysis [9]. The low cost radioactivity free imaging technology called point-of-care ultrasound (POCUS) provides actual time records to support the medical-care. Particularly, lungs ultrasound shows greater sensitivity by identifying the pulmonary pathologies like effusion of pleural cavity, syndrome like alveolar interstitial; Pneumo-thorax, acute heart failure and pneumonia than either computed tomography or a chest scan [10].

This technology directs the ultrasonic waves are focused on the area of interest by using the ultrasound transducer capacitive micro-machined that produces voltage by a membrane. Furthermore, the pockets probe devices are prepared through the following innovative features: linear-measurements; labeling of the anatomic structures; semi-automated dynamic tracking for the automatic estimation of the ejection fraction; for manual out-put adjustment to the limit ultra-sound exposure; mid-line marker to the help with technical guidance; and a real-time thermal and mechanical index displays that enable the user to use the ultrasound safely [9].The application of POCUS is crucial, particularly in environments with limited resources and limited access to other imaging technologies like computed tomography and conventional radiology. Through specialized training, the technique can be acquired quickly [11, 12].

## Methodology

The aim of this study was to assess the capacity of inexperienced Point-of-Care Ultrasonography (POCUS) users to use a handheld device to self-acquire interpretable lung ultrasound images. We postulated that inexperienced users could self-obtain sufficient LUS images for diagnostic purposes with little training, and that these images would differ slightly from expert-obtained scans in reliability.

## Selection of Participants

We sought out healthy adult volunteers who were at least eighteen years old and had no previous medical trainings. Colleagues referred those who fit these requirements to study staff, who then contacted them via phone to recruit them. Participants were considered eligible for participation if they could physically grip a probes on their chest, by means of self-examined by the contestants and then if they were admittance to a computer PC, email-address and the source of internet to which preview through the slides show based presentations, that remained showed to them electronically prior to the study era. It was not necessary to have live or constant access of the internet during the time period of study. Participants with prior experience performing POCUS or training in medicine or imaging were not allowed to participate in this study. The demographic data that the patients provided included their ages, height's, weight, and uppermost formal level of the education.

### Usage of Ultrasound

Using a handheld ultra-sound probe (Butterfly-Network-Inc and Butterfly-iQ) linked to the capable devices like iOS (MAC/Apple, Cupertino-CA), LUS scans were carried out in the homes of the participants. Following their review of the tutorial members remained instructed to conduct the 8-zoneslung ultra-sound on them-selves targeting to produce an inter-pretable of pictures as conceivable in accordance with help of tutorial's instructions. On each side of the thorax, there were two fronts anterior and two side lateral lungs zone. The participants were directed to follow interpretability guidelines in order to get the most inter-pretable clips possible for the each zone. Each POCUS expert scored a clip separately using the previously outlined scoring system in the manner listed below: A score of 0 means that no discernible structures are seen throughout the entire clip; a score of 1 means that the pleural cavity line is semi-partly seen but quality of the clips is not diagnostic; a score of 2 means that the pleural cavity line is semi-partially seen but the picture is adequate for diagnosis; at last a score of 3 means that the pleural cavity line is clearly visible throughout entire clips. Quality scores demonstrated outstanding inter-rater reliability after training (correlation

coefficient of intra class 0.97, 95% CI 0.90–0.99). There was only one interpretability disagreement, and the two raters' agreement on image interpretability was moderate (kappa = 0.64).

## Statistical Analysis

Standard parametric and non-parametric data analysis methods were applied. Using Wilcoxon signed rank sum tests, the quantity of the inter-pretable zone and quality score of the scans got by novices and expert participants were co-related. Using the tests like Chi-square, the magnitudes of inter-pretable scans were compared between the groups.

## Results

For this study, a total of fifty participants were enlisted. Table 1 shows that average age of members were 42.8 years [standard deviation (SD) 15.8], their average BMI (Body Mass Index) was 23.7 kg/m2 (SD 3.1), and 67% of them were male.

**Table 01:** The participants and their number with their body mass index

| **Participants** | **Number** |
|---|---|
| Male | 30 (60%) |
| Female | 20 (40%) |
| **Age (Years)** | |
| 25-35 | 9 (18%) |
| 35-45 | 16 (32%) |
| 45-55 | 15 (30%) |
| 55-65 | 10 (20%) |
| **Body mass index kg/m$^2$** | |
| <20 | 10 (20%) |
| 20-25 | 17 (34%) |
| 25-30 | 13 (26%) |
| 30-40 | 10 (20%) |
| >40 | 0(0%) |

**Table 02:** The quality scores of the scans performed by novices and experts

| **No.** | **Novice score** | **Expert score** | **P-value** | **Novice interpretable** | **Expert interpretable** | **P-value** |
|---|---|---|---|---|---|---|
| **1** | 6 (4-6) | 6 (2-6) | 0.53 | 22.5 | 20 | 0.02 |
| **2** | 6 (6-6) | 6 (6-6) | 1 | 25 | 27 | 1.1 |
| **3** | 6 (2-6) | 6 (4-6) | 0.18 | 22 | 25 | 0.01 |
| **4** | 8 (4.5-8) | 8 (4.5-8) | 0.75 | 28 | 30 | 0.005 |
| **5** | 6 (6-6) | 6 (6-6) | 0.65 | 25 | 23 | 0.01 |
| **6** | 6 (6-6) | 6 (6-6) | 0.23 | 25.5 | 25 | 0.01 |
| **7** | 6 (6-6) | 6 (6-6) | 0.39 | 26 | 26 | 0.02 |
| **8** | 6 (6-6) | 6 (6-6) | 0.14 | 26 | 27 | 0.31 |

Two hundred LUS clips were acquired from POCUS scanners with varying levels of experience. Overall, 84% (n = 201) of the clips obtained by novices were deemed interpretable, which did not differ from 87% (n = 209) of the clips obtained by experts, p = 0.30. The quality scores of the scans performed by novices and experts were not different (median 2.6, IQR 2.3–2.9 for novices, median 2.8, IQR 2.3–3.0, p = 0.09 for experts) (Table 2). There was no difference in the quality scores among the eight distinct zones (P > 0.05 for all).

For novice-obtained scans, a median of 7 out of 8 zones were judged interpretable (IQR 6-8). When co-related to professional obtained scans, the interpretability of scans obtained by novices and experts was not different (median 7 out of 8 zones, IQR 6–8, p = 0.422). The interpretability of

Lung Ultra-Sound (LUS) for every zone didn't change between scans attained by experts and novices when multiple comparisons were taken into account.

Each point-of-care ultrasonography expert scored a clip separately using the previously outlined scoring system in the manner listed below: A score of 0 means that no discernible structures are seen throughout the entire clip; a score of 1 means that pleural cavity line is partially seen but quality of the clips is not detected; a score of 2 means that the pleural cavity line is partially seen but the picture is adequate for diagnosis; at last a score of 3 means that the pleural cavity line is clearly visible throughout entire clip. While score's of 2 and 3 were thought to be of adequate quality for the diagnostic evaluation, score's of 0 and 1 were regarded as non-diagnostic.

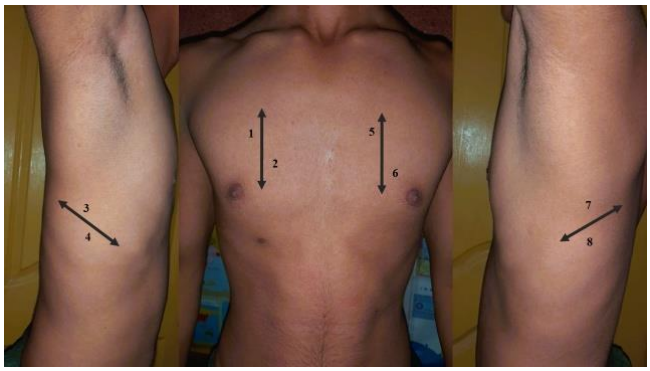
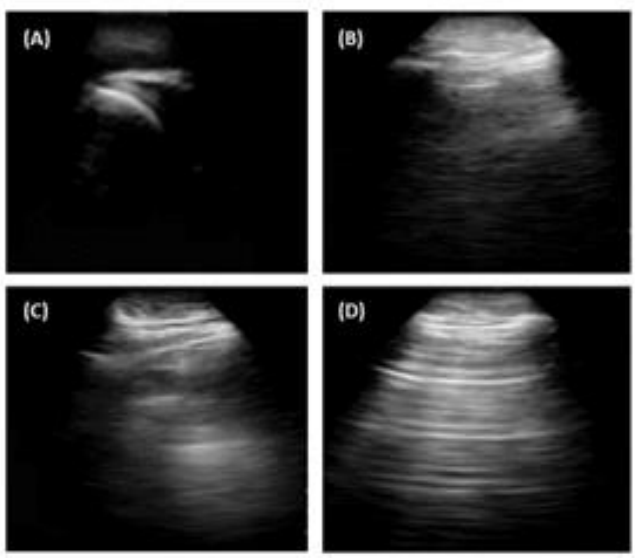



**Figure 1:** Scanning protocols of 8-zones performed by both novices and professionals-sonographers.

1. This score is co-related to the gold standard score, which is the mean of the ratings provided by the professionals.
2. Signed Wilcoxon rank sum test.




Representative image: Score 0 (A) Score 1 (B), Score 2 (C) and Score 3 (D)

Our findings show that even inexperienced Point-of-Care Ultrasonography (POCUS) consumers can independently attain Lung Ultra-Sound (LUS) pictures of the front anterior and side lateral lungs zone without the support of a specialist. Just 66% of the attempts to self-attain posterior lung zone pictures in the previous work were effective.

Through this work, we aimed to develop lung ultra-sound scanning protocols that are simple enough for inexperienced consumers to effectively perform on their own at home. Though, if posterior fields are not imaged, significant findings for some pathological processes might go unnoticed. To determine whether inter-pretable to posterior side of lung zone clip are available for remote patients self-evaluation t, more research is required.

## Conclusion

The portable ultrasound machines of today are remarkably lightweight and equipped with advanced processors and imaging software. High-quality images can be obtained from them, and certain devices have several modes (echocardiography, vascular, color Doppler, and endovaginal

exams, among others). Our findings show that even inexperienced point-of-care ultrasonography consumers can independently attain lung ultra-sound pictures of the front anterior and side lateral lungs zone without the support of a specialist.

This study contributes to the findings of a currently reported by Kirkpatrick et al., that showed the 100% of attempts, inexperienced users using live tele-ultrasound under the guidance of experts were capable to take pictures of the front anterior and side lateral lung zones on their own, with 99.8% of the images being interpreted by experts. Although, a simulation trial, practitioners who were unfamiliar with ultrasound technology were able to quickly reach a satisfactory level of competency in both image acquisition and interpretation. Handheld ultra-sound probes are valued because of their port-ability, ability to share data on the cloud, and telemedicine potential.

These characteristics have the potential to enhance POCUS instruction for faculty and residents as well as perioperative patient care. The physician will especially benefit from being able to carry around a pocket-sized probe that can switch between low- and high-frequency imaging, as well as curved and linear image acquisition. This research contributes to the evidence that POCUS could be a practical method for patients centered, monitoring and diagnostic assessment for diseases like heart failure, that are progressively being treated outside of conventional clinical settings. In order to inform their outpatient medical care, patients with the heart failure are currently requested to regularly check their blood pressure and body weight at home.

Additionally, LUS has been shown to be useful in evaluating acute failure of heart, aggregative factors, and in this population, the presence of B-lines on lung ultra-sound has been connected to higher rates of mortality and morbidity. The difficulties lie in making these methods logistically viable, comprehending the human aspects needed to offer the best mentoring for this method, and advancing AI and machine learning to the point where this resource can be used in remote locations.

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