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A Practical Approach to Lung Ultrasound Training in Sri Lanka

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Lower respiratory tract infections (LRTIs) are the leading cause of death globally in young children and elderly adults (1). Lung ultrasound (LUS) has been established as a viable alternative to chest radiography for LRTI diagnosis, with advantages in resource-limited settings including ease of learning, durability, and point-of-care applications (2–12). In addition, LUS may help predict LRTI severity, as a previously described quantitative LUS score predicted response to certain treatments (13–15).

Despite advantages for resource-limited settings, few reports of LUS training programs in low- and middle-income countries (LMICs) exist (2–4, 16–19). All LMIC LUS training programs were led by experts using a multifaceted curriculum of lectures, hands-on instruction, and practice examinations. Practice examinations were most effective, with trainee competency increasing with

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successive examinations (2, 16–18). Reports of the minimum number of supervised examinations required to demonstrate proficiency ranged from 10 to 25 (3, 17–19).

Here we describe a training program for quantitative LUS conducted at Teaching Hospital Karapitiya (THK) in advance of a prospective cohort study of patients hospitalized with LRTIs. THK is the largest public hospital in southern Sri Lanka. Chest radiography and radiologists are readily available at THK, but computed tomography is only intermittently available.

METHODS

Recent medical school graduates without LUS experience were selected for a training program led by a board-certified specialist radiologist at THK with more than 8 years of LUS experience. Training sessions were taught in three sessions over 2 weeks and focused on quantitative LUS, specifically image acquisition and a 12-zone LUS scoring protocol, as well as diagnosis of select pulmonary pathologies using open-source instruction materials (Table 1) (13, 20–24). All sessions used an ultrasound system (Fujifilm SonoSite Edge II) already available at THK.

The first session focused on image acquisition, including a didactic presentation introducing the I-AIM (Indication, Acquisition, Interpretation, Medical Decision-making) framework and online interactive LUS module followed by hands-on instruction on probe use and image recording. The second session taught a 12-zone LUS scoring protocol using healthy volunteers. The LUS score was determined by identifying the most "severe" of the following aeration patterns for each of the 12 lung zones: 0 = normal aeration; 1 = moderate loss of lung aeration with multiple well-defined B lines; 2 = severe loss of lung aeration with multiple coalescent B lines; and 3 = lung consolidation. The LUS score, ranging between 0 and 36, represented the sum of scores for all zones.

The third session consisted of supervised practice LUS examinations on a curated set of five patients, including normal examinations and conditions featuring a spectrum of lung aeration patterns. Each trainee then performed 40–45 unsupervised LUS examinations over the subsequent 6 weeks on inpatients with suspected LRTIs without reviewing the patients' paper charts, which contained all radiographic and clinical data. The LUS expert audited three to six of these examinations per trainee at random by repeating these examinations within 2 hours of the original trainee LUS examination. Targeted feedback was given to trainees using the images they had acquired.

Concordance between trainee and expert LUS scores was assessed using linearly weighted Cohen's kappa so that closer LUS scores (i.e., difference $\leqslant 2$ points) were weighted differently from LUS scores that were further apart (25). Statistical analyses were performed with STATA statistical software version 17.0 (StataCorp). Ethical approval was obtained from the Faculty of Medicine, University of Ruhuna, Ethical Review Committee (Sri Lanka), and the Duke University Institutional Review Board (United States).

RESULTS

Five recent medical graduates each received a total instruction time (i.e., lectures, hands-on training, and feedback) of 12 hours, representing 36 hours of trainer effort (6 h of group sessions + 6 h of individual instruction per trainee).

By the end of the training program, the average trainee LUS examination

Table 1. Quantitative lung ultrasound training curriculum

Week	Skill	Format and Resources
1	Image acquisition	Didactic presentation (0.5 h) and hands-on practice (1.5 h) • Introductory slideshow lecture on knobology, probe selection, and ultrasound system care • Interactive online module for 3-D visualization of thoracic cavity • Probe settings and adjustments for image acquisition • Image/video recording and storage Resources • I-AIM framework (21) • University of Toronto perioperative interactive education LUS module (23) • Evidence-based recommendations (20)
	Scoring and diagnosis	Hands-on practice with outpatient volunteers (2 h) • Patient positioning and identification of 12 lung zones • Identification and scoring of normal aeration, A-lines, B-lines, and consolidation • Diagnosis of pneumothorax and pleural effusion Resources • 12-zone quantitative LUS protocol (13) • Reference LUS images and videos (22)
2	Scoring and diagnosis	Hands-on practice with hospitalized patients (2 h) • Supervised image/video acquisition and storage • Supervised 12-zone LUS scoring • Supervised diagnosis of pneumothorax and pleural effusion Resources • 12-zone quantitative LUS protocol (13) • Review of reference LUS images and videos (22)
3–6	Independence	Self-directed practice examinations and expert feedback • Independent image acquisition and scoring of 40–45 LUS examinations • Expert audit of three to six LUS examinations within 2 h • Targeted feedback from expert (6 h per trainee) Resources • Review of LUS images acquired by trainee and expert • Review of any aforementioned LUS resources necessary for targeted feedback

Definition of abbreviations: 3-D = three-dimensional; h = hours; I-AIM = Indication, Acquisition, Interpretation, Medical Decision-making; LUS = lung ultrasound.

duration was 10 minutes. LUS scores on audited examinations ranged from 0 to 34 (median score, 10; interquartile range, 3–20). The overall mean difference between trainee and expert LUS scores was 2.2 (95% confidence interval [CI], 0.21, 4.21). Interoperator agreement between trainees and expert was 92.4% (linear weighted Cohen's kappa, 0.72; 95% CI, 0.39, 1.04; $P < 0.001$), aligning with the linear (Pearson) correlation between trainee and expert scores (0.93). For each trainee, there was a trend of increasing agreement with expert LUS scores over three to six audited examinations. Pleural effusions were identified concordantly by expert and trainees; no pneumothoraces were observed.

DISCUSSION

Our findings are consistent with prior quantitative LUS training programs demonstrating increasing agreement between LUS expert and trainee over time; however, we report reaching substantial agreement (i.e., kappa >0.7) in fewer practice examinations, consequently lessening instruction time burden (16, 17, 19, 26). The LUS examination time reported here is within the range (7–15 min) reported by other programs (2, 3, 18, 27). Most importantly, our findings demonstrate that quantitative LUS can be taught in Sri Lanka by a local expert with little time and resources, which bears promise for similar LMICs.

Our study has several limitations. First, these results should be interpreted with caution, given the small sample size, though the degree of expert–trainee agreement is encouraging. Second, there is no record of pulmonary pathologies represented by patients for the practice examinations, though all had suspected LRTIs. Although a review of saved images from trainee examinations demonstrated the full spectrum of lung aeration patterns, the expert–trainee agreement reported here could change given a different case mix. Third, only one LUS expert at one hospital was available for training and auditing, which could bias the observed expert–trainee agreement. Fourth, our study took place at a tertiary hospital with an ultrasound machine and an expert practitioner, which could potentially limit application for locations without these resources. Last, we report a quantitative LUS training program focused on image acquisition and scoring, not diagnosis of pulmonary disease or clinical decision making.

With increasing availability of ultrasound machines worldwide, opportunities to leverage ultrasound technology in LMICs abound. These results demonstrate that quantitative LUS can be easily taught to individuals without prior ultrasound experience using local resources and expertise. Moreover, given the minimal resources employed for the training program, we believe this training program could be implemented in other resource-limited settings.

Conclusions

Quantitative LUS has promising predictive applications for LRTI management and can be effectively taught to clinicians without prior ultrasound experience in Sri Lanka with few locally available resources.

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