ANESTHESIOLOGY

Lung Ultrasound in Emergency and Critically Ill Patients

Number of Supervised Exams to Reach Basic Competence

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ABSTRACT

Background: Lung ultrasound is increasingly used in critically ill patients as an alternative to bedside chest radiography, but the best training method remains uncertain. This study describes a training curriculum allowing trainees to acquire basic competence.

Methods: This multicenter, prospective, and educational study was conducted in 10 Intensive Care Units in Brazil, China, France and Uruguay. One hundred residents, respiratory therapists, and critical care physicians without expertise in transthoracic ultrasound (trainees) were trained by 18 experts. The main study objective was to determine the number of supervised exams required to get the basic competence, defined as the trainees' ability to adequately classify lung regions with normal aeration, interstitial–alveolar syndrome, and lung consolidation. An initial 2-h video lecture provided the rationale for image formation and described the ultrasound patterns commonly observed in critically ill and emergency patients. Each trainee performed 25 bedside ultrasound examinations supervised by an expert. The progression in competence was assessed every five supervised examinations. In a new patient, 12 pulmonary regions were independently classified by the trainee and the expert.

Results: Progression in competence was derived from the analysis of 7,330 lung regions in 2,562 critically ill and emergency patients. After 25 supervised examinations, 80% of lung regions were adequately classified by trainees. The ultrasound examination mean duration was 8 to 10 min in experts and decreased from 19 to 12 min in trainees (after 5 *vs.* 25 supervised examinations). The median training duration was 52 (42, 82) days.

Conclusions: A training curriculum including 25 transthoracic ultrasound examinations supervised by an expert provides the basic skills for diagnosing normal lung aeration, interstitial–alveolar syndrome, and consolidation in emergency and critically ill patients.

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EDITOR'S PERSPECTIVE

What We Already Know about This Topic

- Transthoracic ultrasound may be clinically useful, but training is not standardized, and it remains unclear when naïve trainees have sufficient competency to perform exams unsupervised

What This Article Tells Us That Is New

- A multicenter, international study was conducted in 10 intensive care units among residents and staff in anesthesiology, critical care, emergency medicine, and internal medicine who underwent supervised training, to determine the number of exams required to achieve basic competence
- After 25 supervised examinations, 80% of lung regions were adequately classified by trainees
- Ultrasound exam average duration was 8 to 10 min in experts and decreased from 19 (after 5 exams) to 12 min (after 25 exams) in trainees

Transthoracic ultrasound allows the assessment of pleural space, lung parenchyma, and diaphragm. In critically ill and emergency patients, lung ultrasound appears as an attractive alternative to bedside chest radiography, obviates radiation exposure, shortens the time to obtain pulmonary imaging, and is easily repeatable. The point-of-care use and cost effectiveness have been reviewed in an International Consensus Conference.[1] Transthoracic ultrasound influences clinical decision-making[2] and enables the diagnosis and treatment follow-up in acute respiratory distress

*Members of the APECHO Study Group are listed in the Appendix.

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syndrome,[3] pulmonary edema,[4–6] infectious pneumonia,[5,6] lung contusion,[7] pleural effusion, and pneumothorax.[3,8]

The method required to acquire the basic competence remains debated, and there is no current evidence when naïve trainees can perform exams unsupervised. Establishing the appropriate training curriculum is important for educators, regulatory bodies, and faculty in an era of "competency-based clinical education" impacting patient safety. A study performed on critically ill patients reported a 7-month learning curve.[9] Studies using phantoms, experimental animals, and video clips suggested that a 1-day training markedly improves the competence for diagnosing acute thoracic lesions.[10,11] In fact, most studies focus on specific ultrasound skills: appropriate central venous catheter placement[12] and diagnosis of pulmonary edema,[13] pneumothorax,[10,13] or pleural effusion.[10,14] Introduced at the end of the 1990s in the 38-bed multidisciplinary intensive care unit (ICU) of La Pitié–Salpêtrière Hospital (Sorbonne University of Paris), transthoracic ultrasound was rapidly considered as opening a new era of respiratory imaging. After training residents in anesthesiology and critical care for 10 yr, we acquired the conviction that 25 transthoracic examinations supervised by an expert were enough to acquire basic skills in lung ultrasound. To assess whether such a training course could be applied outside of France, we designed a multicenter international educational study: the APprentissage de l'ECHOgraphie pulmonaire (APECHO) study. This training curriculum was previously shown to be efficient to provide the appropriate skills for measuring the lung ultrasound score,[15] a surrogate of lung aeration in critically ill and emergency patients.[16–18] The main objective of the APECHO Study was to determine the number of supervised exams required to get the basic competence in lung ultrasound. Basic competence was defined as trainees' ability to adequately classify all examined lung regions with normal aeration, interstitial–alveolar syndrome, and lung consolidation.

Materials and Methods

Study Design

The multicenter, international, and educational prospective observational APECHO Study was conducted in 10 ICUs and four countries: Brazil (four ICUs), China (three ICUs), France (two ICUs), and Uruguay (one ICU). During a 16-month period (November 1, 2013, to February 28, 2015), trainees without previous experience in transthoracic lung ultrasound followed an educational curriculum to acquire basic expertise in lung ultrasound. Because the study did not concern biomedical research, the Committee for the Protection of Persons of La Pitié–Salpêtrière Hospital (Committee for the Protection of Persons Ile de France VI) waived written informed consent from patients (session of October 17, 2013).

The transthoracic ultrasound examination was indicated by the physician in charge of the patient. Trainees and experts were not involved in the patients' care. They were unaware of the respiratory disorders indicating transthoracic ultrasound and of abnormalities detected on bedside chest radiography and lung computed tomography. The training course started with a 2-h video lecture providing the rationale for image formation and describing lung ultrasound patterns commonly observed in critically ill and emergency patients. Each trainee downloaded the initial slideshow prepared by one of the authors (J.-J.R.) that was considered the reference. (Ten Powerpoint files corresponding to the whole slideshow supporting the 2-h video lecture can be freely downloaded by connecting to the following Supplemental Digital Content URLs, with the understanding that the source of the slides should be mentioned as J. -J. Rouby, Sorbonne University of Paris France: [1] Normal Aeration and Interstitial Edema, http://links.lww.com/ALN/C148 [2] Pulmonary Edema, http://links.lww.com/ALN/C149 [3] Consolidation Air Bronchogram, http://links.lww.com/ALN/C150 [4] Consolidation Extension, http://links.lww.com/ALN/C151 [5] Consolidation Blood Flow, http://links.lww.com/ALN/C152 [6] Consolidation Lung Abscess, http://links.lww.com/ALN/C153 [7] Pleural Effusion and Pneumothorax, http://links.lww.com/ALN/C154 [8] Performance and LU Score, http://links.lww.com/ALN/C155 [9] LUS Re-aeration and Recruitment 1, http://links.lww.com/ALN/C163 and [10] LUS Re-aeration and Recruitment 2, http://links.lww.com/ALN/C164). Then each trainee had to perform 25 bedside supervised lung ultrasound examinations. Eighteen experts participated in the supervision. To assess the increase in competence over time, every five supervised examinations, the trainee and the expert performed separately a bedside lung ultrasound examination on the same patient (fig. 1A). The trainee's competence was defined as the trainee's ability to adequately classify each of the 12 lung regions examined, with the expert's classification serving as a reference.

Participant Recruitment and Settings

The training curriculum was designed for residents in anesthesiology, critical care, emergency medicine, and internal medicine working in intensive care units and was opened to senior ICU physicians. Residents were informed that the training was an integral part of their intensive care medicine curriculum, whereas seniors' participation was voluntary. The trainees gave their approval and could stop the training course at any time.

The experts were staff members and senior physicians in anesthesiology and critical care medicine, emergency medicine and radiology. Fifteen were trained in the multidisciplinary ICU of La Pitié–Salpêtrière Hospital between 2010 and 2014, over periods ranging from 3 weeks to 14 months. In 2013, a French expert (H.B.) spent 6 weeks in Hangzhou, China, to train future experts of the Department of Emergency Medicine of the 2nd Affiliated Hospital. Each expert had performed at least 500 lung ultrasound examinations in the critical care or emergency environment over a minimum 3-yr period.

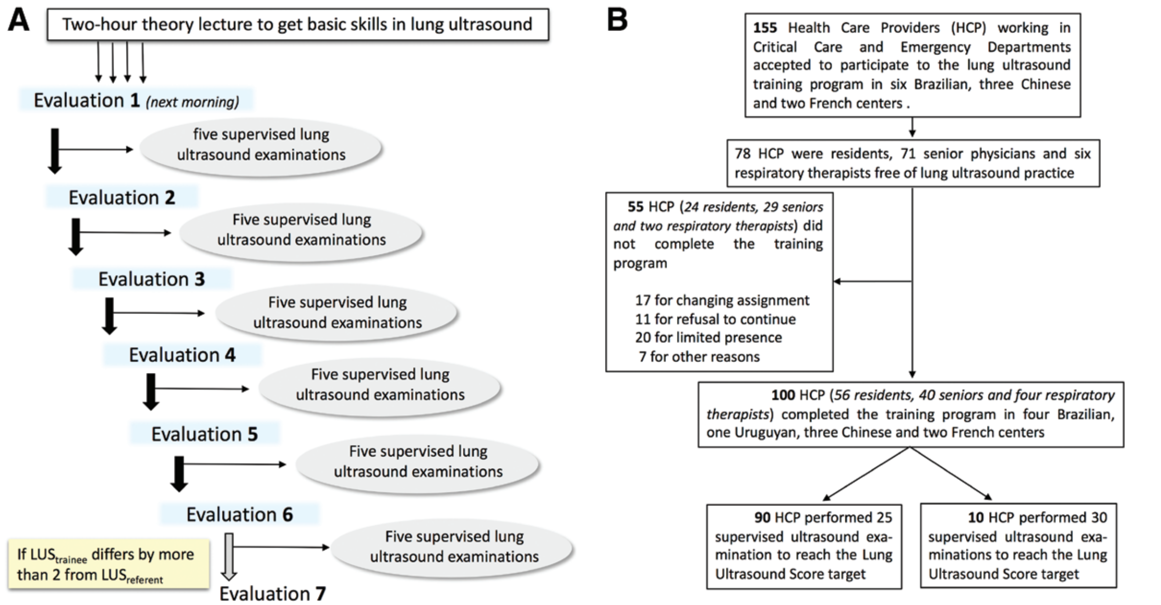

Fig. 1. Design and flow chart of the APECHO protocol. (*A*) APECHO protocol. After a 2-h theory lecture providing rationale for lung ultrasound imaging interpretation (Supplemental Digital Content), six successive and comparative evaluations were performed between trainees and experts, each evaluation being separated by five ultrasound examinations performed by the trainee and supervised by the expert. If on the sixth evaluation, the lung ultrasound score assessed by the trainee was deviating by more than 2 from the lung ultrasound score assessed by the expert, five additional supervised ultrasound examinations were performed by the trainee, followed by a seventh comparative evaluation. (*B*) Among 155 trainees initially selected, 100 completed the protocol. HCP, healthcare providers; $LUS_{referent}$, lung ultrasound score assessed by the expert; $LUS_{trainee}$, lung ultrasound score assessed by the trainee.

The sonographers used in the different centers are listed in the Supplemental Digital Content (http://links.lww.com/ALN/C156). The procedures of hygiene and disinfection were considered as an integral part of the training although not standardized (http://links.lww.com/ALN/C156).

Lung Ultrasound Curriculum and the APECHO Study

The training curriculum concerned healthcare providers without expertise in transthoracic ultrasound. The APECHO Study focused on the number of supervised lung ultrasound examinations required to get the basic competence for diagnosing normal aeration, interstitial–alveolar syndrome, and consolidation in critically ill and emergency patients. The ability of differentiating interstitial syndrome from alveolar edema was considered as a high expertise level and was not included in the acquisition of basic competence. The training for identification and quantification of pleural effusion for diagnosis of pneumothorax and diaphragm dysfunction was an integral part of the training curriculum but not included in the APECHO Study because it requires different protocols and times of acquisition.[14]

Supervision included the selection of an appropriate acoustic window and the interpretation of ultrasound images. In case of trainee's difficulties, video clips that were recorded during the supervised examination could be reviewed to facilitate learning.

A low frequency 5-MHz convex probe, fitting with intercostal spaces, was used in 80% of centers. To facilitate the analysis of the pleural anatomy and lung sliding, the emission frequency was frequently increased to 9 to 12 MHz. More rarely a low frequency linear probe was used. Twelve regions of interest were examined (fig. 2). Patients with large dressings and subcutaneous emphysema were excluded for the evaluation. Trainees and experts classified each examined region according to the worst parenchymal lung ultrasound pattern selected among five entities: (1) normal aeration, defined as the presence of lung sliding, less than three vertical B lines, and multiple horizontal A lines; (2) interstitial–alveolar syndrome, defined as the presence of multiple B lines either spaced or coalescent; (3) interstitial syndrome, defined as the presence of more than two spaced B lines or coalescent B lines, detected in a limited portion of the intercostal space and issued from the pleural line or subpleural consolidations of at least 5 mm; (4) pulmonary edema, defined as the presence of coalescent B lines detected in several intercostal spaces, occupying the whole intercostal space and issued from the pleural line or subpleural consolidations of at least 5 mm; and (5) lung consolidation, defined as a tissue pattern

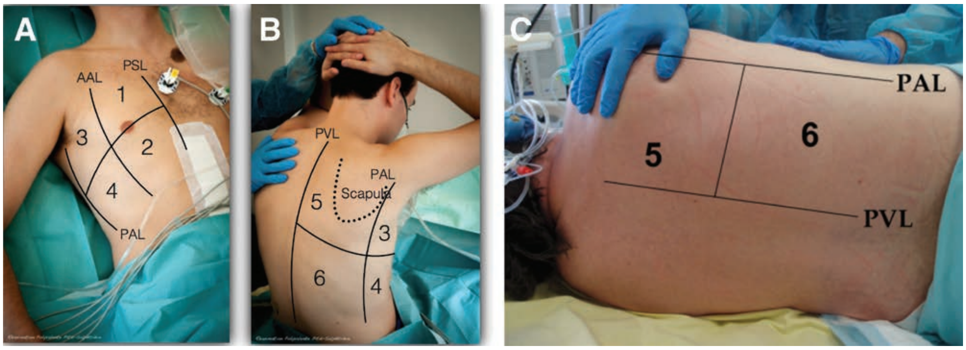

Fig. 2. Technique for transthoracic lung ultrasound examination. Six regions of interest are examined on each side (twelve regions for a complete ultrasound examination). In each region, all intercostal spaces are carefully examined, and the worst ultrasound pattern characterizes the region (0, normal aeration; 1, interstitial syndrome; 2, alveolar edema; and 3, lung consolidation). (*A*) Anterior (*regions 1* and *2*) and lateral lung regions (*regions 3* and *4*) delineated by the parasternal line (PSL), anterior axillary line (AAL), posterior axillary line (PAL), and mammillary line in patients positioned in the semirecumbent position. (*B*) Posterior lung regions (*regions 5* and *6*) delineated by the paravertebral line (PVL), posterior axillary line, and prolonged mammillary line in patients who can be positioned in the semirecumbent position. To enlarge the acoustic window in the upper posterior region (between the paravertebral line and the inside edge of the scapula), the patient should keep his hands over his head. (*C*) Posterior lung regions (*regions 5* and *6*) in patients who cannot be positioned in the semirecumbent position. To facilitate the ultrasound approach of posterior lung regions, such patients should be positioned in the lateral decubitus position. This image is reproduced from reference 17 with permission.

with or without the presence of static and/or dynamic air bronchograms.[3] The presence of pulmonary blood flow detected using Doppler imaging within the consolidation[3,17] was highly suggestive of inflammation and/or infection. The lung ultrasound score was calculated as previously described.[15,16,18]

Data Collection

Trainees' and experts' initials corresponding to the lung ultrasound examination, indications for lung ultrasound examination, patients' data, lung ultrasound diagnosis region by region, and lung ultrasound score were prospectively collected in an electronic Case Report Form that was common to all participating centers. The data were centralized and analyzed in Paris according to inclusions. In case of missing data, the center was contacted to complete the data.

Ethics Approval and Consent to Participate

The study was approved by the Committee for the Protection of Persons of La Pitié–Salpêtrière Hospital (Committee for the Protection of Persons Ile de France VI, session of October 17, 2013). Because the study did not concern biomedical research and did not modify routine care of patients, the Committee for the Protection of Persons waived written informed consent from patients. Residents had to attend the course. Seniors' participation was voluntary. Trainees gave their oral approval and could stop the training course at any time.

Statistical Analysis

Statistical analysis is the primary and preplanned analysis of collected data. The data concerning lung ultrasound score have been reported in a previously published manuscript.[15]

The sample size of the present study was based on a previous pilot study. In 2013, we performed a study in naïve residents and seniors to determine the time required to get basic competence. Comparisons between trainees and experts were performed immediately after an initial 2-h video lecture, 15 days later, and 1, 2, and 3 months later. The result was that 2 to 3 months were required to get the basic competence, during which 20 to 30 supervised lung ultrasound examinations were performed. We then decided to target the number of supervised examinations rather than the training time. In the present study, we decided to accept a risk of error lower than 10%, and we calculated that a minimum of 50 trainees was necessary. Because of the disparities concerning the training implementation between France, China, and Brazil, we finally enrolled 100 trainees and obtained a precision (half-width of 95% CI) of 6%.

Categorical variables are expressed as numbers (%), and continuous variables are expressed as medians (25 to 75% interquartile range) or means ± SD according to data distribution, assessed using a Shapiro–Wilk test. Data obtained in trainees who did not complete the training curriculum were not taken into consideration (Supplemental Digital Content, http://links.lww.com/ALN/C156). Agreement for normal aeration, interstitial–alveolar syndrome, interstitial syndrome, alveolar edema, and consolidation was expressed as the percentage of lung regions identically classified by the trainees and the experts. When 80% or more of lung regions were adequately classified, concordance was considered as clinically acceptable. Intraclass coefficient correlation was not used because the score of each region of interest, the unit of analysis, was dependent on the score of the adjacent unit. Acquisition of competence over time was defined as a percentage of agreement between the trainee and the expert above 80%, considering all regions independently of their ultrasound pattern. The acquisition of basic competence over time was statistically assessed using Fisher's exact test between two successive evaluations. Duration of lung ultrasound examination performed by trainees and experts on the same patient was compared using a paired Wilcoxon test. For each evaluation, duration of lung ultrasound examination performed by French, Chinese, and Brazilian trainees was compared using a Kruskal–Wallis test, followed by a two-by-two multiple comparison (Steel–Dwass–Critchlow–Fligner procedure). Duration of training between France, China, and Brazil was compared using a Kruskal–Wallis test followed by a two-by-two multiple comparison (Steel–Dwass–Critchlow–Fligner procedure). Statistical analyses were computed with SPSS v13.0 (SPSS, USA) and SigmaStat v3.5 (SystatS, USA). By convention, the α risk was taken in a two-tailed hypothesis. $P < 0.05$ indicated statistical significance.

Results

Trainees and Patients

As shown in figure 1B, 155 healthcare providers participated into the study. Among the 100 trainees who completed the training course, 56 were residents (anesthesiology and/or critical care medicine, n = 41; emergency medicine, n = 10; and internal medicine, n = 5), 40 were senior staff members (anesthesiology and/or critical care medicine, n = 28; emergency medicine, n = 9; and internal medicine, n = 3), and 4 were critical care respiratory therapists. The number of trainees enrolled per center is shown in table S1 of the Supplemental Digital Content (http://links.lww.com/ALN/C156). The training protocol was performed in 2,562 critically ill and emergency patients. Comparative evaluations were performed between the trainees and the experts in 370 critically ill patients. The main indications for lung ultrasound examination were pneumonia (86 of 317, 27%), hypoxia (76 of 317, 24%), and acute respiratory distress syndrome (67 of 317, 21%). The patients' characteristics, the indications for lung ultrasound examination and hygiene, and the cleaning and disinfection procedures are reported in tables S2 to S4 of the Supplemental Digital Content (http://links.lww.com/ALN/C156).

Competence Acquisition

As shown in figure 3A, more than 80% of all examined lung regions were adequately classified by trainees after 25 supervised lung ultrasound examinations. As shown in figure 3B, more than 80% of lung regions with normal aeration were adequately classified by trainees after 20 supervised examinations. Lung regions with interstitial syndrome were adequately classified by 76 and 78% of trainees after 25 and 30 supervised lung ultrasound examinations (fig. 2SA of Supplemental Digital Content, http://links.lww.com/ALN/C156). Lung regions with alveolar edema were adequately classified by 62 and 64% of trainees after 25 and 30 supervised examinations (fig. 2SB of the Supplemental Digital Content, http://links.lww.com/ALN/C156). When grouping interstitial syndrome and alveolar edema, 80% of the 2,898 lung regions with interstitial–alveolar syndrome were adequately classified by trainees after 25 supervised lung ultrasound examinations and 93% after 30 supervised examinations (fig. 3C). As shown in figure 3D, more than 80% of lung regions with consolidation were adequately classified by trainees after 25 supervised examinations. The acquisition of competence for the lung ultrasound score is provided in figure 3S of the Supplemental Digital Content (http://links.lww.com/ALN/C156). Individual curve per trainee and ultrasound pattern are displayed in figures S1 (A–C) and S2 (C and D; http://links.lww.com/ALN/C156).

Median time required to perform a complete ultrasound examination varied between 8 and 9 min in experts and did not change over the successive evaluations (fig. 4). For trainees, median time was 19 min after 5 supervised examinations and 12 min after 25 supervised examinations. Chinese trainees were more rapid than Brazilian and French trainees: 9.7 (7.8, 11.2) min *versus* 14.3 (12.7, 16.7) min and 13.1 (10.6, 15.2) min, respectively, $P = 0.005$). The median acquisition time of basic competence was 62 (42, 82) days in the 10 ICUs (Brazil, China, France and Uruguay), 47 (36, 82) days in Chinese ICUs, 62 (49, 75) days in French ICUs, and 119 (89, 151) days in Brazilian and Uruguayan ICUs. It was shorter in China than in France ($P = 0.007$) and Brazil and Uruguay ($P = 0.001$) and shorter in France than in Brazil and Uruguay ($P = 0.011$).

Discussion

The prospective, international, multicenter, and educational APECHO Study performed in 100 trainees without expertise in lung ultrasound shows: (1) basic competence to diagnose normal aeration, interstitial–alveolar syndrome, and consolidation in critically ill patients was acquired after 25 lung ultrasound examinations supervised by an expert; (2) high-level expertise to differentiate interstitial syndrome from alveolar edema required more than 30 supervised lung ultrasound examinations; (3) time to acquire basic competence varied between 5 weeks and 5 months; (4) expert's median time to perform a complete transthoracic examination ranged between 7 and 10 min; and (5) trainee's median time to perform a complete transthoracic examination decreased from 19 min at the beginning to 12 min at the end of the training curriculum.

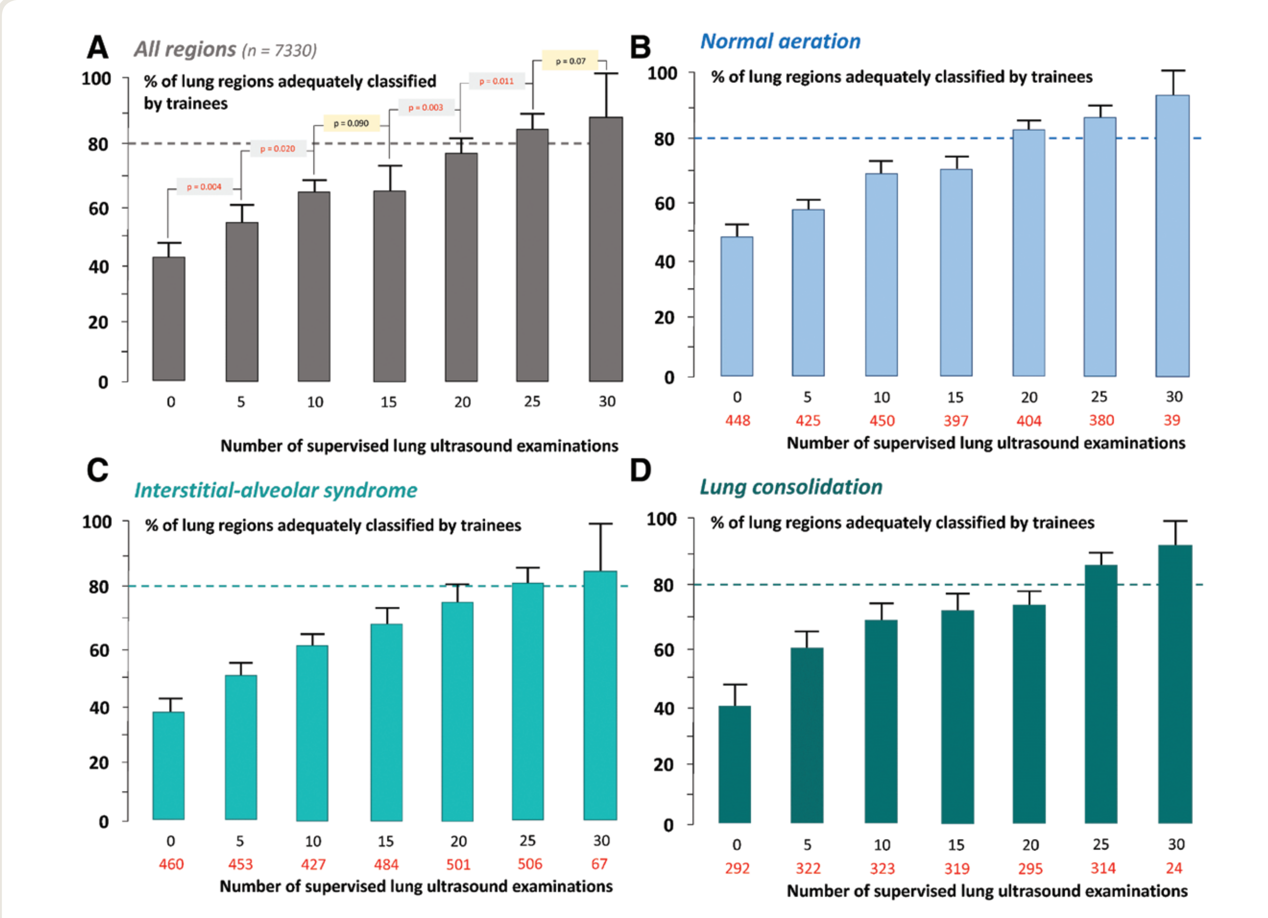

Fig. 3. Acquisition of basic lung ultrasound competence in 100 trainees from Brazil, China, France, and Uruguay. Acquisition of competence is based on successive and comparative evaluations performed independently in the same patient by trainees and experts. Each evaluation is separated by five ultrasound examinations performed by the trainee and supervised by the expert. The agreement between trainees and experts for basic ultrasound patterns is expressed as percentages of concordance (%) between trainees and experts for all examined lung regions (*A*), normal aeration (*B*), interstitial–alveolar syndrome (*C*), and lung consolidation (*D*). In each panel, 95% CI are represented. *Red numbers* indicate the number of lung regions classified by the expert for a given evaluation. Percentages indicate the concordance between trainees and expert, with the expert's classification serving as reference. A total of 7,330 lung regions were examined: 2,543 were classified as normally aerated, 2,898 were classified as characterized by interstitial–alveolar syndrome, and 1,889 were classified as characterized by lung consolidation. Acquisition of competence over time independently of the ultrasound pattern (*A*) was statistically analyzed using Fisher's exact test between each successive evaluation with corresponding *P* values.

Lung ultrasound training appears less demanding than transthoracic echocardiography training, where competence acquisition requires 50 (basic skills) to 750 (high-level expertise) supervised examinations.[19,20] There is an intrinsic reason for this shorter training duration. Acute respiratory distress syndrome or ventilator-associated pneumonia as any type of lung injury decreases lung aeration. The abnormal interface between the pulmonary gas and the augmented extravascular lung water creates vertical artifacts called B lines,[21–23] whereas the normal aeration produces horizontal artifacts called A lines.[1] Lung consolidation is detected as a tissue pattern with or without air bronchograms.[24] Therefore, the basic training curriculum can focus on only three ultrasound patterns: normal aeration, interstitial–alveolar syndrome (moderate to severe loss of aeration), and lung consolidation (complete loss of aeration). In addition, the interexpert variability lower than 5%[5,24] facilitates the supervision of trainees.

Any training in the ICU is conflicting with daily patients' clinical care. Our study reflects this difficulty, explaining the high attrition rate. The availability of trainees and experts according to daily clinical load, as well as their motivation, also markedly affects the length of time required to get the basic competence. To test the applicability of the training curriculum, it was performed in different countries with different academic courses, health systems, hospital organizations, and medical practices. It also covered a wide range of respiratory conditions commonly observed in critical care medicine

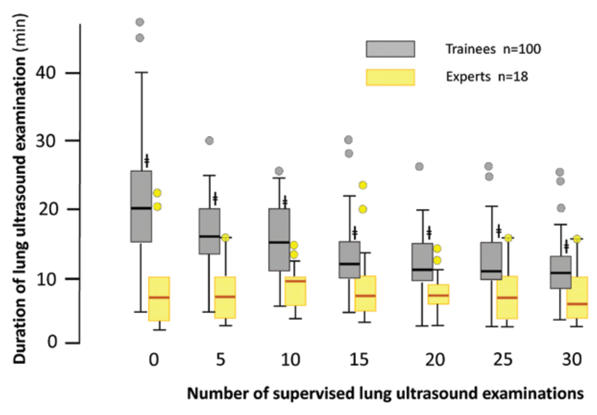

Fig. 4. Duration of complete transthoracic lung ultrasound examination. During six comparative evaluations, complete transthoracic lung ultrasound examination was performed by 100 trainees (*gray bars*) and 18 experts (*yellow bars*) to assess lung regions with normal aeration, interstitial syndrome and alveolar edema. In 10 trainees, a seventh evaluation was performed because lung ultrasound score by the trainee differed from the lung ultrasound score by the expert by more than 2. The median duration (interquartile and extremes) significantly decreased over time in trainees and remained stable in experts, ranging between 7 and 10 min. ‡, $P < 0.01$ between trainees and experts using a two-by-two multiple comparison (Steel–Dwass–Critchlow–Fligner procedure).

(tables S2 and S3 of the Supplemental Digital Content, http://links.lww.com/ALN/C156). Another strength of the study is the homogeneous training of experts despite their geographical dispersion. Most of them were trained in Paris or locally by Parisian instructors, ensuring a similar evaluation for Chinese, French, Uruguayan, and Brazilian trainees.

The study has also some methodologic limitations. First, the number of trainees in Brazil and Uruguay was small compared with France and China, questioning the possibility of generalizing the data obtained to other Brazilian and Uruguayan ICUs. Second, 55 of 155 trainees did not complete the training curriculum. This introduces a potential bias because presumably, the most motivated participants were faster and better. This issue reflects true life, however, in which motivation and changes in affectation are factors influencing any training curriculum success. Third, we did not test whether 25 to 30 supervised exams in a short time period (1 week) is as adequate as doing those same exams over several weeks or months. Many healthcare providers hoping to learn lung ultrasound do so in short courses.[25] Fourth, the study does not address the potential utility of associating a self-training to the clinical training curriculum.[26] Recently, hand ultrasound on a wet foam dressing material has been suggested to be effective for trainees lacking experience in detecting B lines.[11,27,28] Although our training curriculum is effective to provide adequate skills for interstitial–alveolar syndrome, it is less effective for providing separate skills for interstitial syndrome and pulmonary edema (fig. 2S). That a pretraining simulation on wet foam models may have facilitated the detection of different types of B lines and shortened the learning curve for lung ultrasound high-level skill acquisition is likely. The use of phantom could also facilitate the acquisition of skills for pneumothorax detection.[28] As pointed out recently, the systematic use of linear probes and the assessment of percentage of occupied pleura by B lines could facilitate the ability of trainees in distinguishing moderate from severe loss of aeration.[18]

Recommendations concerning bedside lung ultrasound training in ICUs are lacking. In addition to simulation training on phantoms, competence acquisition is based on supervised bedside lung ultrasound examinations performed on patients, preceded by a theory lecture and self-learning.[9,25,26,29] The course can be concentrated over a few days or included in the general critical care training. It can target a general training or focus on the acquisition of specific skills in various categories of healthcare providers.[9–14,26]

Conclusions

Our study provides convincing evidence that 20 to 25 supervised bedside lung ultrasound examinations over a period of 6 to 17 weeks allow healthcare providers without expertise in lung ultrasound to acquire basic skills for assessing normal lung aeration, interstitial–alveolar syndrome, and lung consolidation.

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Competing Interests

The authors declare no competing interests.

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