Supplemental Digital Content files

Lung Ultrasound in Emergency and Critically Ill Patients: Number of Supervised Exams to Reach Basic Competence

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Trainees' participation per centre

As shown in the table 1, 100 trainees participated into the training course in 10 centres in France, China, Brazil and Uruguay

Paris Pitié-Salpêtrière (Dr Charlotte Arbelot, **Pr JJ Rouby**)	n = 31
Hangzhou 2nd Affiliated Emergency hospital (Dr Yuzhi Gao, **Pr Mao Zhang**)	n = 19
Peking Union Medical College hospital (Dr Wang Chunyao, **Pr Du Bin**)	n = 15
Beijing Peking People's Hospital (Dr Jie Lv, **Pr Youzhong An**)	n =14
Sao Paulo Albert Eistein Hospital (Pr Carmen Barbas, **Pr Guilherme Schettino**)	n = 7
Porto Alegre Ernesto Dornelles Hospital (Dr Felippe Dexheimer, **Pr PTR Dalcin**)	n = 5
Clermont-Ferrand Destaing Hospital (Dr Sébastien Perbet, **Pr Jean-M Constantin**)	n = 5
Sao Paulo Das Clinicas Hospital (Dr Fabiola Prior, **Pr Luiz Malbouisson**)	n = 2
Salvador Hospital de Bahia (Dr Julio Neves, **Pr Emidio JS Lima**)	n=1
Montevideo Das Clinicas Hospital (Dr Andres Cebey, **Pr Alberto Biestro**)	n=1

Table 1 Number of trainees by centre who completed the curriculum course. *The names in round brackets indicate the main investigator and the medical director (bold) of each center. The medical director of La Pitié-Salpêtrière center in Paris changed in March 2019: Pr Jean-Michel Constantin left Clermont-Ferrand for Paris and became the new medical director of the Multidisciplinary ICU. Pr Jean-Jacques Rouby who initiated the study, was the former medical director.*

Patient data collection

The following data concerning emergency and critically ill patients in whom lung ultrasound examination was performed by trainees and referents were prospectively collected: age, sex, weight, height, body mass index, admission criteria (medical disease, surgical procedure and trauma), the Sepsis-related Organ Failure Assessment (SOFA) score on admission,[1] the Simplified Acute Physiology Score (SAPS II) at admission,[2] the type of ventilation during the ultrasound examination (spontaneous or mechanical), PaO_2/FiO_2 in mechanically ventilated patients immediately before lung ultrasound examination. The clinical indication for lung ultrasound examination was also recorded. The quality of the acoustic window was rated by the senior physician as good or average and a picture of the patient's chest was taken.

Statistical analysis

We did not perform an "Intention to Teach" analysis by analogy to the "Intention to Treat" analysis recommended in randomized trials testing new therapies. The aim of our multicentre, international, educational prospective observational study was to determine the number of supervised exams required to get basic competence in lung ultrasound performed in critically ill patients. If a trainee who actually did not receive the 25-30 supervised ultrasound examination had been included as a trainee who received the full training curriculum, then it will indicate very little about the efficacy of the training curriculum. Therefore, trainees who did not perform the full training curriculum for any reason (changing assignment, refusal to continue, limited presence, absence for health problem, conflict with the referent) were not included in the final analysis. We did not compare our training curriculum with a self-learning curriculum, and therefore the "Intention to Teach" analysis does not seem to be warranted.

Clinical indication for lung ultrasound examination and characteristics of patients who served for evaluations

Clinical characteristics of patients in whom lung ultrasound examination was performed by trainees and referents are summarized in table 2. There was a predominance of males with 8 % of patients having a body mass index (BMI) > 30. As attested by high SOFA and SAPS II scores, most of the patients were critically ill. Both scores, however, were significantly higher in France than in China and Brazil-Uruguay and significantly higher in Brazil-Uruguay than in China. In addition, the incidence of trauma patients was significantly higher in China than in France and Brazil-Uruguay.

	Clinical characteristics							Cause of admission		
	Age	Male (%)	BMI	MV (%)	SOFA	SAPS II	PaO_2/FiO_2^+	Medicine (%)	Surgery (%)	Trauma (%)
PARIS *(Pitié-Salpêtière Hosp)* n = 116	60 ± 18	74	25 ± 4.7	40	9.5 ± 4.5	51 ± 20	242 ± 110	28	71	0
CLERMONT-FERRAND n= 19	67 ± 12	79	28 ± 4.6	42	6.4 ± 2.9	47 ± 19	230 ± 128	61	33	6
France n = 135	***61 ± 17***	***75***	***25 ± 4.7***	***60***	***9 ± 4.5*** *†	***50 ± 20*** *	***237 ± 114***	***33***	***65***	***1***
BEIJING (PUMCH) n= 6	NA	NA	22 (20, 23)	16	7 (7,9)	49 (36, 56)	143 (92,163)	100	0	0
BEIJING (*Peking univ People' Hosp*) n= 75	66 ± 14	60	24 ± 3.9	53	NA	NA	NA	16	80	4
HANGZHOU n= 80	55 ± 15	86	23 ± 2.0	17	4 (3, 5)	42 (34, 48)	250 ± 78	22	0	78
China **n= 161**	***61 ± 15***	***69***	***24 ± 3.3***	***65***	***4 (3, 5)*** ‡	***42 (32, 46)*** ‡	***240 ± 87***	***22***	***43***	***35*** *‡
SAO PAULO (*Das Clinicas Hosp*) n= 11	56 ± 19	63	26 ± 2.5	27	7 (4, 10)	49 (46, 65)	276 ± 67	73	18	9
SAO PAULO (*Albert Einstein Hosp*) n= 28	69 ± 18	57	25 ± 4.1	36	8 (3, 10)	47 (33, 64)	329 ± 145	21	79	0
PORTO ALEGRE *(E Dornelles Hosp)* n= 26	78 ± 13	68	NA	56	5 (1, 12°	53 (27, 61)	301± 135	72	18	10
MONTEVIDEO *(Hosp de Clinicas)* n= 4	55 (25,69)	75	26 (25,28)	50	3 (2, 4)	35 (31, 38)	187 (173, 200)	25	25	50
SALVADOR *(Hosp de Bahia)* n= 6	68 (19,72)	50	25 (24,28)	17	6 (3, 8)	47 (34, 61)	190 (188, 200)	67	0	16
Brazil Uruguay **n= 75**	***68 ± 18***	***68***	***26 ± 4.0***	***73***	***7 (3, 9)***	***49 (34, 63)***	***308 ± 129***	***41***	***51***	***8***
All centers n = 371	***61 ± 19***	**72**	***25 ± 3.9***	61	***9 (6, 12)***	***49 (35, 65)***	***245 ± 102***	**29**	**53**	**18**

Table 2 Characteristics of the patients that served for the evaluations between trainees and referents. *BMI = Body Mass Index; MV = Mechanical Ventilation; SOFA = Sepsis-related Organ Failure Assessment Score; SPAS II = Simplified Acute Physiology Score II. PUMCH = Peking Union Medical College Hospital. NA = non available; + PaO_2/FiO_2 values concern exclusively ventilated patients. Mean ± SD or median (25th, 75th percentile). SOFA and SAPSII were compared using a Kruskal Wallis test; cause*

of admission were compared using tests of independence following the Monte Carlo method and the G2 Wilks. * indicates p < 0.01 France vs China; † indicates p <0.001 France vs Brazil-Uruguay; ‡ indicates p <0.001 China vs Brazil-Uruguay.

As shown in table 3, clinical indication for lung ultrasound in patients who were examined for evaluations covered a broad spectrum of acute respiratory diseases encountered in emergency and critically ill patients but differed between countries.

	Bacterial pneumonia (%)	ARDS (%)	Congestive Heart Failure (%)	Pleural Effusion (%)	Hypoxia (%)	Other (COPD, Interstitial pneumonia, dyspnea, bronchectasis) (%)
PARIS *Pitié-Salpêtrière hosp* n= 116	6	35	10	9	40	0
CLERMOND-FERRAND n= 19	5	16	16	47	16	0
France n=135 (95 % CI)	**6** (2, 10)*†	**31** (23, 39) *	**12** (6, 17) *	**14** (8, 20) †	**37** (29, 45) †	**0** *
BEIJING *Peking Union Med College hosp* n= 6	33	0	17	0	0	50
BEIJING *Beijing People hospital* n= 75	55	26	0	0	19	0
HANGZHOU *2nd Affiliated hospital* n= 80	6	35	10	9	40	0
China n=161 (95 % CI)	**32** (25, 40)	**13** (8, 18)	**4** (1, 7) ‡	**7** (3, 11)‡	**25** (18, 32) ‡	**19** (13, 25) ‡
SAÕ PAULO *Das Clinicas hospital* n= 11	56	11	22	0	11	0
SAÕ PAULO *Albert Einstein hospital* n= 28	12	24	30	0	0	34
PORTO ALEGRE *Ernesto Dornelles hosp* n= 28	36	18	18	0	28	0
SALVADOR *Hospital de Bahia* n= 6	17	66	0	0	17	0
MONTEVIDEO *Hospital de Clinicas* n= 4	33	17	0	0	33	17
Brazil-Uruguay n=75 (95 % CI)	**26** (17, 37)	**18** (10, 27)	**24** (14, 34)	**0**	**7** (1, 12)	**25** (15, 35)
All centers n= 371 (95 % CI)	**27** (22, 31)	**21** (17, 25)	**11** (8, 14)	**11** (5, 11)	**24** (20, 28)	**9** (6, 12)

Table 3 Indications for Lung Ultrasound in the patients who served for the evaluations. *CI = 95 % confidence interval; ARDS = Acute Respiratory Distress Syndrome; COPD = Chronic Obstructive Pulmonary Disease. Indications of Lung Ultrasound were compared using tests of independence following the Monte Carlo method and the G2 Wilks. * indicates p<0.05 France vs China; † indicates p<0.05 France vs Brazil-Uruguay; ‡ indicates p<0.05 China vs Brazil-Uruguay***.**

Indication for ARDS was significantly more frequent in France than in China. Indication for hypoxemia was significantly more frequent in France and China than in Brazil-Uruguay. Indication for pneumonia was significantly less frequent in France than in China and Brazil-Uruguay. Indications for chronic respiratory diseases and dyspnea were absent in France and more frequent in Brazil-Uruguay than in China. Indication for congestive heart failure was significantly more frequent in Brazil than in China and France. Lung ultrasound examination for pleural effusion was significantly less frequent in Brazil than in China and France.

Probes, sonographers and procedures of cleaning and disinfection

The sonographers used in the different centers were: Acuson S2000™ SIEMENS HEALTH CARE GmbH® (Erlanger, Germany), M9™ MINDRAY (Shenzen, China), CX50™ PHILLIPS HEALTHCARE (Bothel WA, USA), MyLab Gold25™ ESAOTE (Genova, Italy), SonixTouchQ+™ ULTRASONIX (Richmond, Canada) Sonosite EdgeII SONOSITE® (Washington DC, USA)

Procedures used to prevent dissemination of microorganisms within the ICU or Emergency ward were considered as an integral part of the training. Hygiene rules and cleaning and disinfection procedures were not standardized. At the end of the study, each center completed a questionnaire describing the procedures used to prevent dissemination of microorganisms within the ICU. As shown in Table 4, handwashing before and after lung ultrasound examination as well as cleaning of the probe, cords, sonographer surfaces and keyboard after ultrasound examination were performed by most of the centers. The use of gloves during the procedure was used by half of the centers. Disposable single-use suit, breathing gear, disposable shoes protection and disposable cap were either not used or used by a minority of centers.

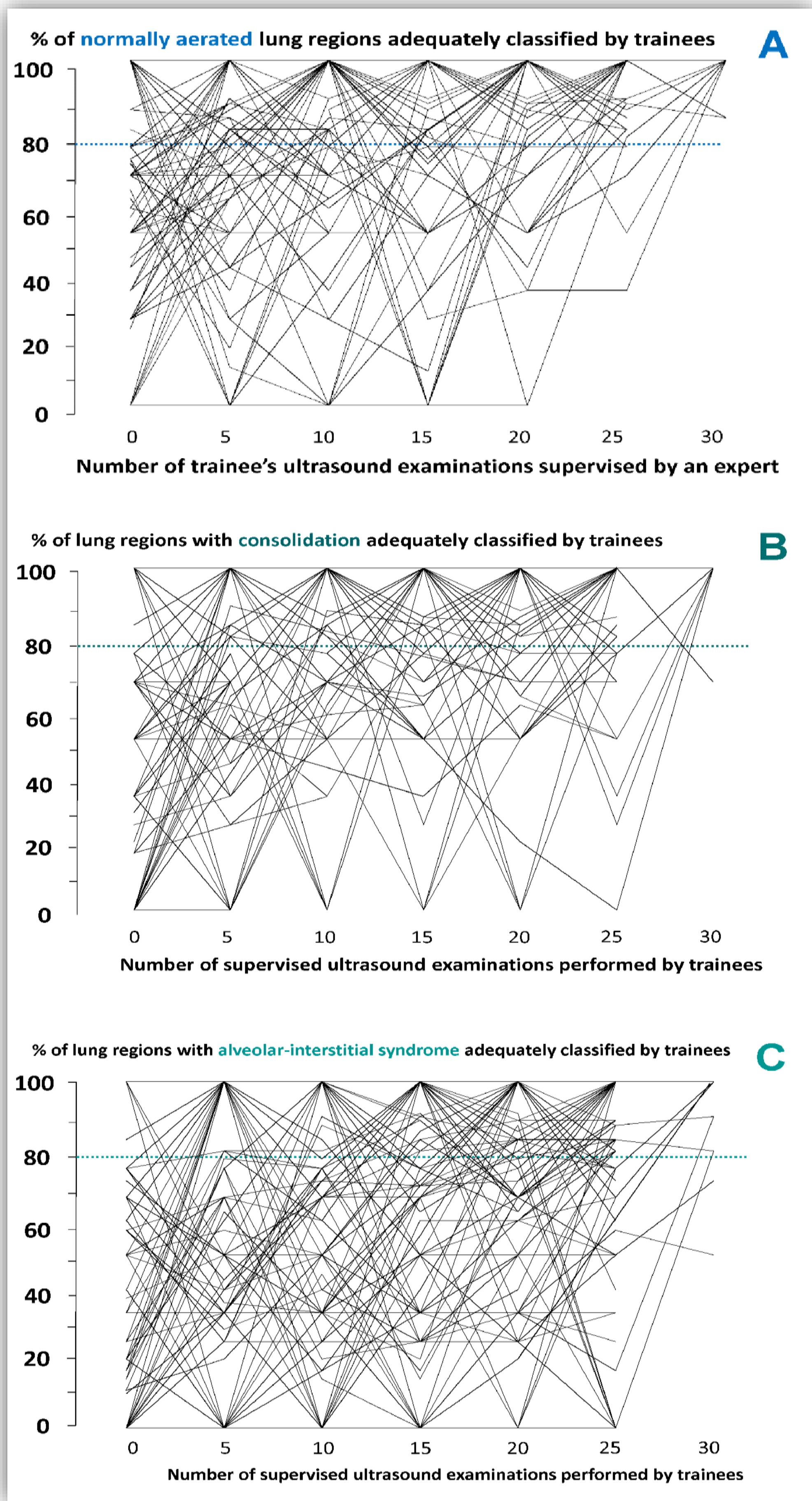
Cleaning of the probe with hydro-alcoholic solution	n=3
Cleaning of the probe with other solution	*Surfa'safe™* n=1 *Wipes™* n=4 Water n=1
Cleaning of the keyboard with hydro-alcoholic solution	n=6
Cleaning of the keyboard with other solution	*Surfa'safe™* n=1 *Wipes™* n = 2
Cleaning of the cords with hydro-alcoholic solution	n=6
Cleaning of the cords with other solution	*Surfa'safe™* n = 1 *Wipes™* n = 3
Cleaning of the sonographer surfaces with hydro-alcoholic solution	n = 6
Cleaning of the sonographer surfaces with other solution	*Surfa'safe™* n = 1 *Wipe™s* n = 2
Handwashing with hydro-alcoholic solution *before* ultrasound examination	n = 8
Handwashing with hydro-alcoholic solution *after* ultrasound examination	n = 7
The examiner wear gloves during the procedure	n = 5
The examiner wears a disposable single-use suit during the procedure	n = 1
The examiner wears disposable protection on his shoes	n = 0
The examiner wears breathing gear during the procedure	n = 3
The examiner wears disposable cap on his head during the procedure	n = 0

Table 4 Procedures of hygiene, cleaning and disinfection in the 10 centers participating to the study.

Individual acquisition of competence for normal aeration, consolidation and alveolar interstitial syndrome is shown in figure S1 A-C.

For a given lung ultrasound examination serving for evalua-tion, individual agreement bet-ween the trainee and the expert was determined as the percentage of lung regions with normal aeration, consolidation and alveolar inter-stitial syndrome adequately classified by the trainee. The agreement was therefore partly depending upon the number of lung regions characterized by the ultrasound pattern. When the ultrasound pattern was observed in a single region, agreement was either 0 or 100%, thereby tending to under or overestimate the agreement. As a consequence, individual curves are more an estimate of competence acquisition than a true learning curve. Obtaining true learning curve for a given ultrasound pattern would have implied to select patients with at least four lung regions exhibiting the ultrasound pattern.

Fig 1S Individual curves showing the acquisition of competence for diagnosis of normal aeration (A), consolidation (B) and alveolar-interstitial syndrome (C) 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. For a given evaluation, the agreement between the trainee and the expert is expressed as the percentage of lung regions with normal aeration, consolidation and alveolar-interstitial syndrome adequately classified by the trainee. Experts classified 2,493 lung regions as normally aerated, 2898 as characterized by interstitial-alveolar syndrome, and 1,889 as characterized by lung consolidation.



Individual acquisition of competence for interstitial syndrome and pulmonary edema

As shown in figure 2S A and C, the mean agreement for diagnosing interstitial syndrome was ≥ 80% from the 5th evaluation, attesting the acquisition of competence with time. Individual curves of competence acquisition show a high initial variability decreasing with the successive evaluations. As shown in figure 2S B and D, the mean agreement for diagnosing interstitial syndrome was ≥ 60% from the 5th evaluation, attesting the limitation of competence acquisition with time. Individual curves of competence acquisition show a high initial variability over the successive evaluations.

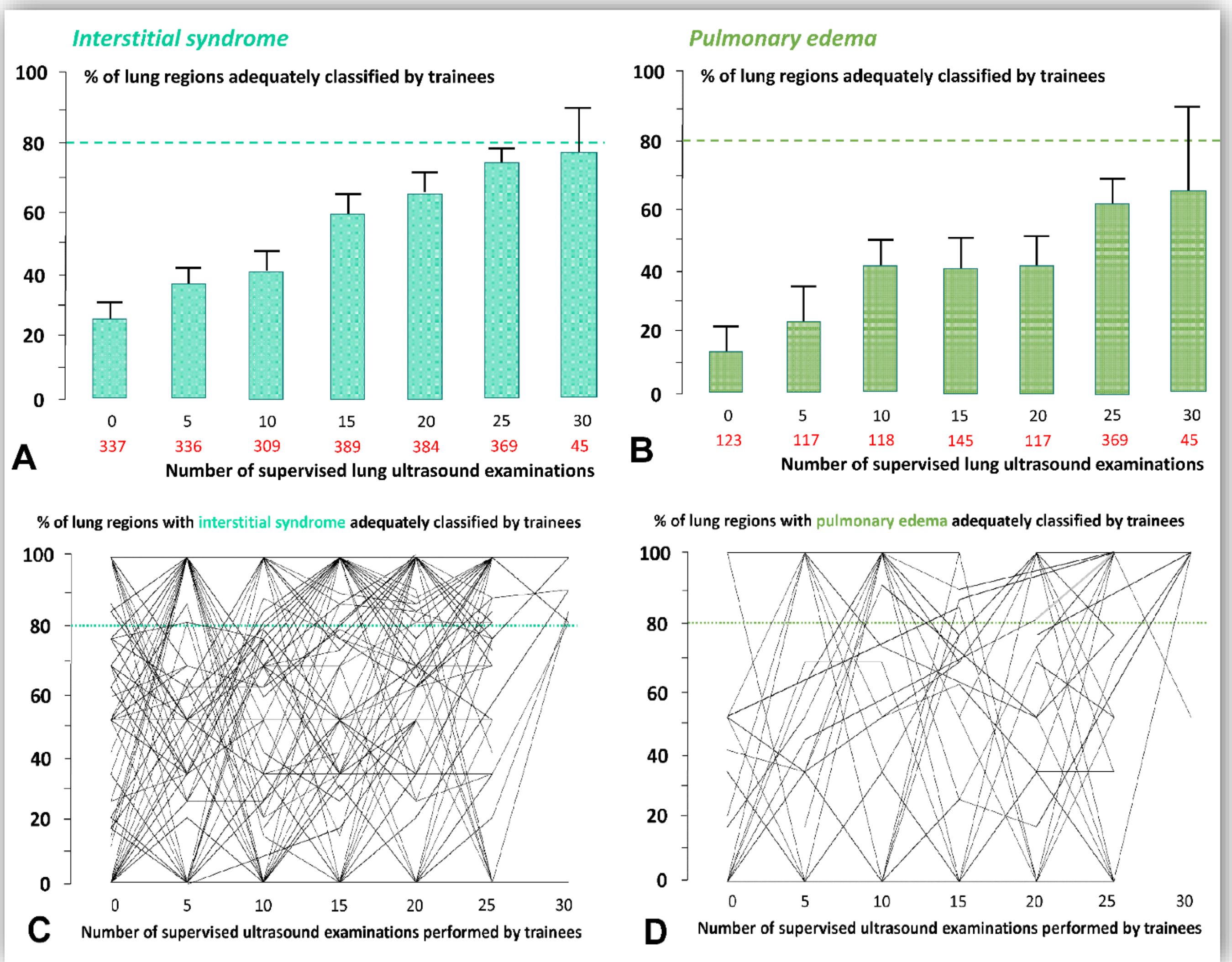


Fig 2S Acquisition of competence for diagnosis of interstitial syndrome and alveolar edema in 100 trainees from Brazil, China, France and Uruguay. *Acquisition of competence is based on successive and comparative evaluations performed independently in the same patient by trainees and experts. Each evaluation is separated by five ultrasound examinations performed by the trainee and supervised by the expert. The mean agreement between trainees and experts is expressed as the percentage of lung regions* *with interstitial syndrome (fig 2S A) and with pulmonary edema adequately classified by trainees (fig 2S B). Ninety five % confidence intervals are represented. Red numbers indicate the number of lung regions classified by the expert for a given evaluation. A total of 2,169 lung regions were classified as characterized by interstitial syndrome and 769 as characterized by pulmonary edema. The individual agreement is shown in figures 2S C and 2S D*

Acquisition competence for Lung Ultrasound Score

As shown in figure 3S, Tau Kendal's coefficients for LUS quantitative values correlations for agreement were ≥ 0.8 from the 5th evaluation, attesting the acquisition of competence with time.

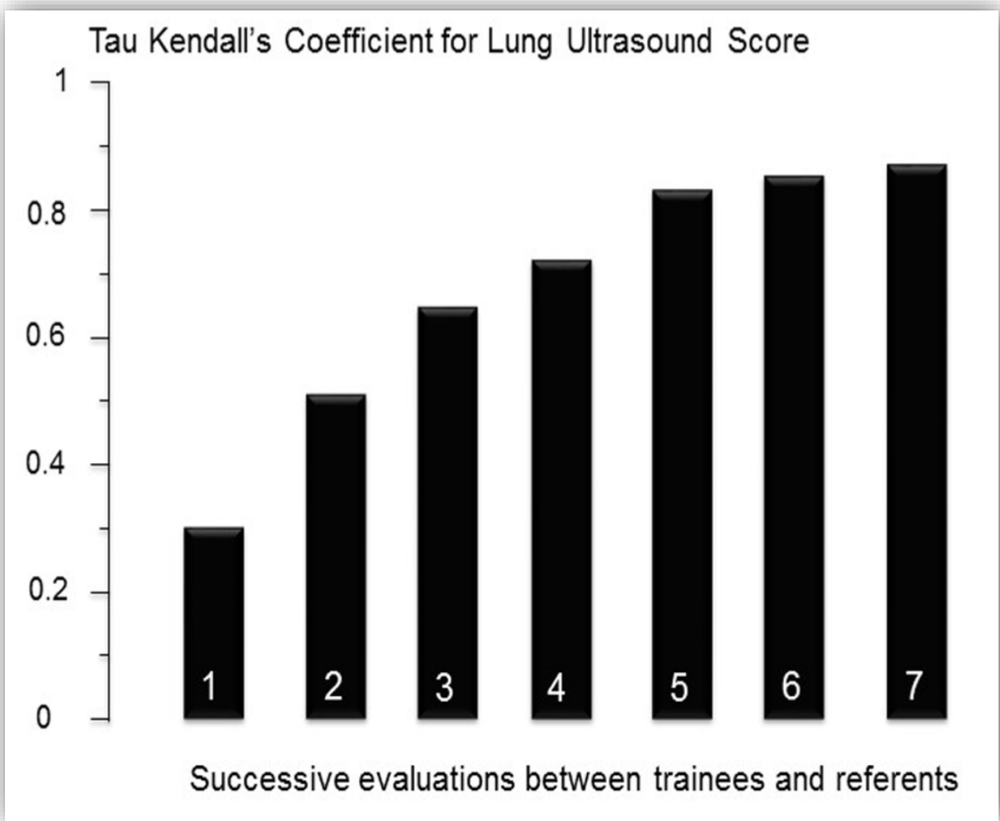


Fig 3S Degree of agrement and concordance between Lung Ultrasound Score assessed by trainees and experts**.** Lung Ultrasound Score was assessed by trainees and referents in the same patient during 6 or 7 evaluations. The first evaluation was performed 2-hour after a theoretical lecture providing rationale for lung ultrasound imaging. Further evaluations were separated by five ultrasound examinations performed by the trainee and supervised by the referent. Intra-class correlation was used to test the Lung Ultrasound Score agreement defined as $LUS_{trainee} = LUS_{referent} \pm 2$. Tau Kendall's coefficient was used to test the numerical agreement between $LUS_{trainee}$ and $LUS_{referent}$

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2. Le Gall JR, Lemeshow S, Saulnier F. A new Simplified Acute Physiology Score (SAPS II) based on a European/North American multicenter study. JAMA 1993;270: 2957-63. [Erratum, JAMA 1994;271:1321]