RESEARCH ARTICLE

Acquisition and retention of lung ultrasound skills by respiratory therapists: A curriculum for respiratory therapists

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A Young, D Wu, F Myslik, D Burke, M Stephens, R Arntfield. Acquisition and retention of lung ultrasound skills by respiratory therapists: A curriculum for respiratory therapists. Can J Respir Ther 2023;59:26–32. doi: 10.29390/cjrt-2021-077.

Purpose: Lung point-of-care ultrasound (POCUS) is a versatile bedside tool. The utility of POCUS has grown during the coronavirus disease 2019 pandemic, as it allows clinicians to obtain real-time images without requiring transport of the patient outside the intensive care unit. As respiratory therapists (RTs) are involved in caring for those with respiratory failure, there is a good rationale for their adoption of lung ultrasound. However, no training standards have been defined. Our objective was to develop and implement a training programme for RTs to achieve and sustain competence in lung ultrasound.

Methods: This was a single-centre, prospective, single-cohort observational study. A total of 10 RTs completed our curriculum and were tasked with independently completing and interpreting 10 initial lung ultrasound exams and 3 subsequent exams after a 6-week interim period. All exams were blindly overread by a local expert in lung ultrasound.

Results: After completing the curriculum, RTs were able to acquire and accurately interpret their images over 85% of the time. They were more successful in the upper lung zone image acquisition and interpretation compared with the lower lung zones. After 6 weeks, the RTs' lung POCUS skills remained stable, and their lower lung zone image interpretation improved. The RTs reported that their confidence improved throughout the study.

Conclusion: The RTs in our study have demonstrated competence in acquisition and interpretation of upper lung zone images. They have also reported confidence in acquiring and interpreting upper lung zone images. More experience appears to be required to gain competence and confidence in lower lung zone ultrasound. Next steps would be to repeat the present study with a higher number of RTs completing at least 20 lung POCUS studies.

Key Words: *competency; critical care; curriculum; point-of-care; respiratory therapy education; ultrasound*

INTRODUCTION

Lung point-of-care ultrasound (POCUS) has been shown to be a versatile tool in the assessment of critically ill patients. It is known to have high sensitivity and specificity compared with traditional chest x-rays for some pathologies [1–3]. The utility of having POCUS at the bedside has grown during the coronavirus disease 2019 pandemic. It allows clinicians to obtain real-time images without requiring transport of the patient outside the intensive care unit (ICU) for computerized tomography scan. This avoids putting severely hypoxemic patients at risk of decompensation and avoids exposing further personnel to coronavirus disease 2019. Nurse practitioners, physiotherapists and other allied health team members have also recently started learning to use point-of-care lung ultrasound in their assessments of patients in the emergency department and critical care settings [4–6]. Literature exists for the training of physicians, medical students, residents, nurse practitioners, paramedics and physiotherapists in echocardiography and lung ultrasound [7–13]. There are few studies regarding the ability of respiratory therapists (RTs) to accurately perform lung POCUS [14]. As RTs are routinely involved in caring for patients with respiratory failure, and are often among the first health care providers to assess patients with acute respiratory decompensation, there is good rationale for their adoption of point-of-care lung ultrasound. Lung POCUS would provide the RTs with further important information in addition to the information from their routine assessments that could then be relayed to the treating physicians that could potentially change management compared with when only routine assessments without lung POCUS are performed. However, no training standards have been defined. Therefore, our objective was to develop and implement a novel training programme for RTs to achieve and sustain competence in lung ultrasound. We hypothesize that the RTs will become competent in basic lung POCUS (based on the relevant portions of the American College of Chest Physicians (*ACCP) statement on competence in critical care ultrasound* [15] [Appendix 1])[1] and defined as acquiring and interpreting lung ultrasound images accurately 80% of the time or more as noted in Arbelot et al [16]) on completion of the training and demonstrate retention of their skills 6 weeks after the initial evaluation.

METHODS

Ethics approval for the present study was received from the Western University Health Sciences Research Ethics Board. This was a single-centre, prospective, single-cohort observational study. A total of 10 RTs (working in a tertiary ICU in an academic teaching hospital: Victoria Hospital in London, Ontario, Canada) were identified by senior RT management as candidates to complete the lung POCUS training. Inclusion criteria: having at least 5 years' experience as registered RTs (RRTs) and being part of the critical care outreach team. Exclusion criteria: having less than 5 years' experience as an RRT, and not working as part of the critical care outreach team. They were also chosen based on

[1]Supplementary materials are available at https://www.cjrt.ca/wp-content/uploads/Supplement-cjrt-2021-077.zip

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Published online at https://www.cjrt.ca on 20 January 2023

the RT group's schedule such that all clinical duties could continue to be completed. RT participation was voluntary and written informed consent was obtained.

Pre-intervention survey

The RTs were asked to complete a 4-question online survey regarding their previous lung POCUS experience before starting the programme (Appendix 2) [1].

Intervention

The RTs then completed the 1.5-h didactic portion of our curriculum, which consisted of three online videos and additional readings reviewing lung ultrasound basics. They were required to pass an online quiz by scoring 80% or more before moving on to the practical portion of the curriculum (Appendix 3) [1]. The practical portion consisted of a single 3-h hands-on training session in which RTs were placed in groups of 3 to 4 with one instructor. Instructors were a final-year ICU fellow (AY) with demonstrated competence in lung ultrasound based on a 2-year longitudinal critical care ultrasonography curriculum for ICU fellows with over 50 lung ultrasounds completed and evaluated as satisfactorily acquired and interpreted or better by local experts in critical care ultrasound (RA, FM, VL), and a medical student (DW) who had completed online didactic training and completed over 10 lung ultrasounds evaluated as satisfactorily acquired and interpreted or better by the same local experts in critical care ultrasound. The medical student's instruction of RTs was supervised by the final-year ICU fellow. The RTs had the opportunity to scan three healthy volunteers and one to two ICU patients with their instructors present to provide feedback.

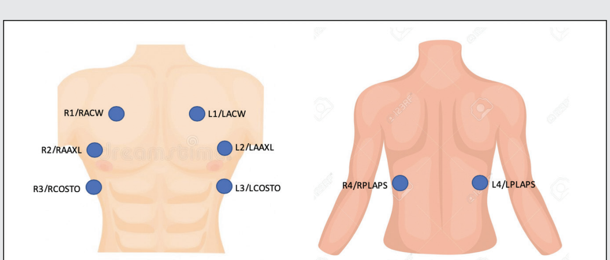
Post-intervention initial evaluation

After the training was complete, RTs were tasked with completing 10 lung ultrasound exams on adult medical, surgical, ward and intensive care inpatients with respiratory issues such as hypoxemia, hypercarbia, tachypnea, shortness of breath or respiratory distress during their shifts within 3 months of completing training. This number of exams over this period was chosen to provide ample time for the RTs to complete a basic number of scans during unprotected work time. Scan requirements included two upper lung zone images (anterior chest wall and anterior axillary zones) on each side, and one or two lower lung zone images (either costophrenic or posterolateral alveolar pleural syndrome zones) on each side (Figure 1). An interpretation of their images marked on a standardized form was required (Appendix 4 – Figure 1) [1]. They were required to indicate whether lung sliding (1 point), and an A-line or B-line pattern (1 point) was present in the four upper lung zones (and were therefore scored out of 8 in this section). They also indicated whether lung curtain (1 point), consolidation (1 point) or pleural effusion (1 point) were present in the two lower lung zones (total score of 6 possible in this section). Image acquisition and interpretation was recorded on QPath (Telexy, Maple Ridge, BC, Canada), our POCUS quality assurance software. The RT's level of confidence in their image acquisition and interpretation was also recorded using a 4-point scale.

The RT's lung ultrasound studies were reviewed on QPath by a blinded local expert (FM, RA, VL) in point-of-care lung ultrasound, and remote quality assurance for each exam was provided using a standardized feedback form (Appendix 4 – Figure 2) [1]. The interpretability of the images was determined by adequate depiction of the relevant anatomical structures that typify each standard view and that permit accurate interpretation. Accuracy of interpretation was determined based on the correct identification of (or acknowledgement of the absence of) standard lung ultrasound patterns (lung sliding, A lines, B lines, lung curtain, consolidation or pleural effusion) by RTs.

FIGURE 1

Lung zones to be scanned. AAXL anterior axillary line; ACW anterior chest wall; COSTO costophrenic angle; L1–L4 left; PLAPS posterolateral alveolar pleural syndrome; R1–R4 right. (Left image courtesy of Ylivdesign and Dreamstime [17]; Right image courtesy of 123RF Limited [18])



Statistical analysis

The absolute number (n) and proportion (%) of interpretable images and accurate interpretations were calculated as a dichotomous outcome. Continuous data were presented as means ± standard deviations. The number and proportion (%) of studies in which RTs had high, moderate, low and no confidence were also calculated. The relationship between the RTs' confidence and accuracy was also explored. The absolute number and proportion (%) of accurately interpreted studies with high/moderate or low/no confidence were calculated, as was the proportion (%) of inaccurately interpreted studies with high/moderate or low/no confidence.

Interim period

Following completion of the initial 10 ultrasounds, a 6-week interim period occurred where RTs were able, but not required, to complete further lung ultrasounds. They were provided feedback on these images as in the *post-intervention evaluation period.* This time interval was chosen based on a similar study reviewing the implementation of a transesophageal echocardiography training programme for emergency physicians [19].

Follow-up evaluation

After this 6-week period, the RTs were asked to complete three further lung POCUS studies, which were subject to the same workflow, to assess for retention of their newly acquired lung ultrasound skills. The judged quality of image generation and interpretation in the initial phase and at the 6-week mark formed the basis of competence determination and skill retention.

Final questionnaire

Following completion of a total of 13 ultrasound scans the RTs were asked to fill out a final, anonymous questionnaire regarding their experience participating in the acquisition and retention of lung ultrasound skills by respiratory therapists (A-LURT) lung ultrasound curriculum (Appendix 5) [1].

RESULTS

The first 10 RTs approached by the senior RT management at our centre voluntarily participated in the A-LURT study.

Pre-intervention survey results

RTs completed a survey regarding their experiences with lung POCUS before participating in the present study. We received responses from all 10 RTs. All had observed at least one lung POCUS performed by a physician or other health care professional before beginning the study. Six RTs had observed more than ten lung ultrasounds. None of the RTs had previously performed a lung POCUS themselves. Six RTs stated that they were "not confident", three stated that they were "neutral" and one stated they were "confident" in their ability to generate lung POCUS images. Seven stated they were "not confident", two stated they were "neutral" and one stated they were "confident" in their ability to interpret lung POCUS images.

FIGURE 2

Proportion of interpretable lung point-of-care ultrasound (POCUS) images (%) from the initial 10 scans performed by the respiratory therapists after completing the acquisition and retention of lung ultrasound skills by respiratory therapists POCUS curriculum. Upper lung zones: anterior chest wall and anterior axillary line. Lower lung zones: costophrenic angle and posterolateral alveolar pleural syndrome

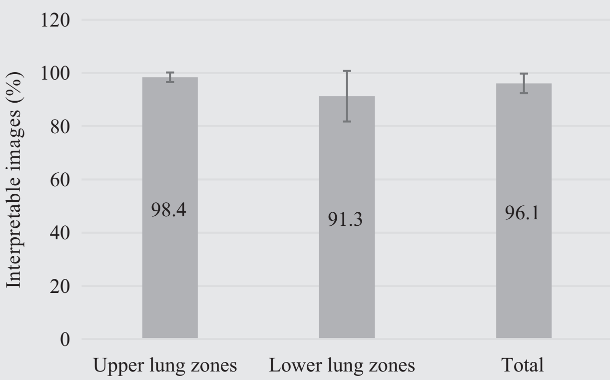
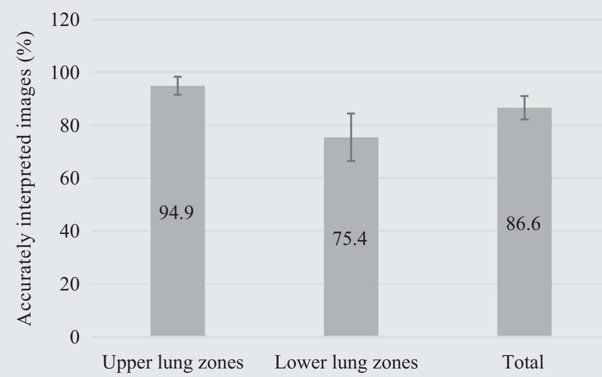


FIGURE 3

Proportion of accurately interpreted lung point-of-care ultrasound (POCUS) images (%) from the initial 10 scans performed by the respiratory therapists after completing the acquisition and retention of lung ultrasound skills by respiratory therapists POCUS curriculum. Upper lung zones: anterior chest wall and anterior axillary line. Lower lung zones: costophrenic angle and posterolateral alveolar pleural syndrome)



Intervention

Ten RTs completed the didactic and practical portions of our A-LURT lung POCUS curriculum.

Post-intervention results

The RTs then began performing lung POCUS scans on hospital or ICU inpatients. Nine out of 10 RTs completed the required initial 10 lung POCUS scans. Eight RTs completed only four lung POCUS scans because of illness. A total of 94 scans were completed. Scans were judged on image acquisition and interpretation accuracy. After the initial 10 scans were completed there was a 6-week interim period. During this time, only two RTs completed extra lung POCUS scans. RT5 completed one interim study, and RT9 completed three interim studies. They received feedback on these scans, but the results were not included in the image interpretability and interpretation accuracy calculations. After the 6-week interim period, the nine remaining RTs' retention of lung POCUS skills was assessed. They completed three final lung POCUS studies. A total of 27 scans were completed. Results are presented below.

Initial evaluation results

Image acquisition results from the initial 10 lung POCUS scans are shown in Figure 2. Overall, 536/558 (96.1±3.7% – mean±standard deviations) of the lung POCUS images acquired by RTs were interpretable. A total of 368/374 (98.4±1.8%) of upper lung zone images were interpretable while 168/184 (91.3±9.5%) of lower lung zone images were interpretable. Image interpretation results are shown in Figure 3. RTs were able to accurately identify presence/absence of lung sliding, A-line/B-line pattern, lung consolidation, pleural effusion and lung curtain 1,107/1,278 (86.6±4.4%) times in the lung POCUS images. Interpretation in the upper lung zones was accurate 700/738 (94.9±3.4%) times. Interpretation in the lower lung zones was accurate 407/540 (75.4±9.0%) times.

Self-reported confidence

RTs reported that they were highly confident in their images and interpretations in 219/564 (38.8%) of the images. They reported high confidence in 194/376 (51.6%) of the upper lung zone images. In the lower lung zones, they reported high confidence in only 25/188 (13.3%) of the images. Results are presented in Figure 4.

Confidence and accuracy relationship

The relationship between RTs' confidence and image interpretation accuracy is shown in Figure 5. When the RTs reported low or no confidence in their images and interpretations, they accurately and inaccurately interpreted their images 60/104 (57.7%) and 44/104 (42.3%) times, respectively. When they reported high or moderate confidence, they accurately and inaccurately interpreted their images 365/438 (83.3%) and 73/438 (16.7%) times, respectively. When high and moderate confidence studies were separated it was noted that when RTs reported high or moderate confidence, they inaccurately interpreted their images 17/438 (3.9%) and 56/438 (12.8%) times, respectively.

Interim period

During the 6-week interim period, only two RTs completed extra lung POCUS scans. RT5 completed one interim study, and RT9 completed three interim studies. They received feedback on these scans, but the results were not included in the image interpretability and interpretation accuracy calculations.

Follow-up evaluation results

After the 6-week interim period, overall 153/161 (95±5.2%) of the images in the final three scans were interpretable, and 333/374 (89.0±10.2%) of the images were accurately interpreted. 105/108 (97.2±5.9%) of upper lung zone images and 48/53 (90.6±12.1%) of lower lung zone images were interpretable. A total of 201/212 (94.8±5.8%) of upper lung zone images and 132/162 (81.5±17.4%) of lower lung zone images were accurately interpreted. Results are shown in Figures 6 and 7.

Self-reported confidence

After the 6-week interim period, RTs reported increased confidence. They reported that they were highly confident in their images and interpretations 101/162 (62.4%) of the time. They were highly confident in the upper lung zone images in 87/108 (80.6%) of the images. In the lower lung zones, they reported high confidence in only 14/54 (25.9%) of the images. Results are presented in Figure 8.

FIGURE 4

Proportion of lung ultrasound scans (%) in which respiratory therapists self-reported high, moderate, low, no confidence or when they did not report their confidence level in the initial 10 scans. Upper lung zones: anterior chest wall and anterior axillary line. Lower lung zones: costophrenic angle and posterolateral alveolar pleural syndrome

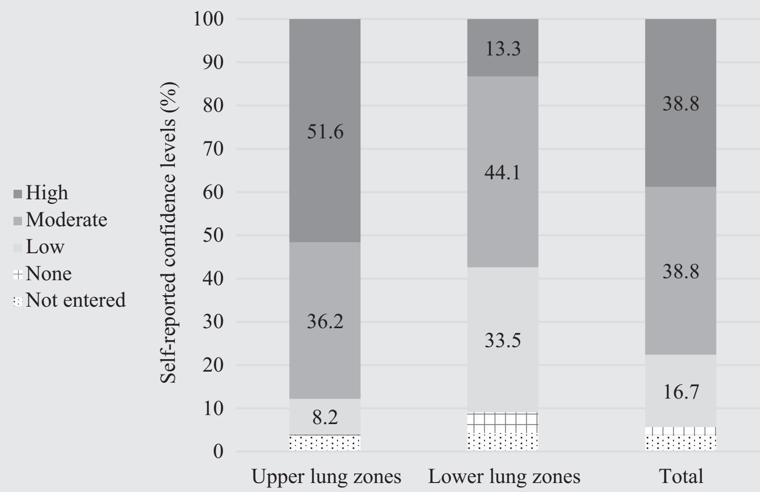


FIGURE 5

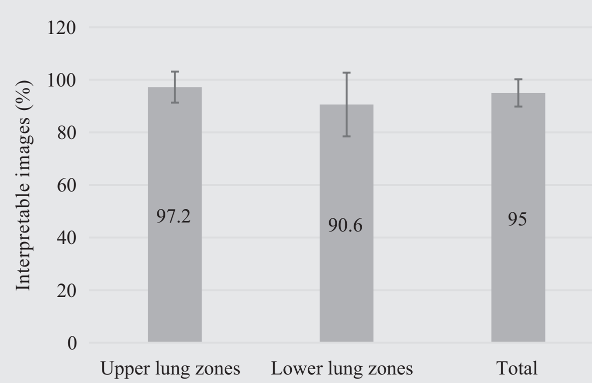
Confidence and accuracy relationship (initial 10 scans)

	Confidence	
Accuracy	**High/moderate (%)**	**Low/none (%)**
Accurate	83.3	57.7
Inaccurate	16.7	42.3

	High	Moderate
Inaccurate	3.9%	12.8%

FIGURE 6

Proportion of interpretable lung point-of-care ultrasound (POCUS) images (%) from the final three scans performed by the respiratory therapists after completing the acquisition and retention of lung ultrasound skills by respiratory therapists POCUS curriculum. Upper lung zones: anterior chest wall and anterior axillary line. Lower lung zones: costophrenic angle and posterolateral alveolar pleural syndrome



Confidence and accuracy relationship

The relationship between RTs' confidence and accuracy was again calculated after the 6-week interim period. The results are shown in Figure 9. When the RTs reported low or no confidence in their images and interpretations, they accurately and inaccurately interpreted their images 4/8 (50%) times in both cases. When they reported high or moderate confidence, they accurately and inaccurately interpreted their images 127/148 (85.8%) and 21/148 (14.2%) times, respectively. When high and moderate confidence studies were separated, it was noted that when RTs reported high or moderate confidence, they inaccurately interpreted their images 6/148 (4.1%) and 15/148 (10.1%) times, respectively.

Final questionnaire

We received responses from 8 of the 9 RTs who completed the A-LURT curriculum and subsequently completed 13 lung POCUS studies. All eight RTs responded that they enjoyed participating in the curriculum. Seven out of eight RTs agreed or strongly agreed that the online didactic videos were helpful to learn lung POCUS.

Six out of eight RTs agreed or strongly agreed that the practical training session was helpful to master image acquisition. Five out of eight RTs felt that the hands-on training sessions were too short. Two RTs commented that they would have liked to practice more on real patients rather than volunteers particularly so that they could practice the lower lung zone views on more challenging patients.

All 8 RTs who responded stated that the 13 lung POCUS scans that they completed and the feedback that they received regarding those scans was helpful or very helpful to become more competent in lung POCUS.

All eight RTs felt the number of scans required as part of the training was appropriate. All eight felt competent to obtain and interpret upper lung zone images after scanning six patients. Four out of eight RTs felt they needed 10 scans and three felt they needed more than 13 scans to become competent to obtain and interpret lower lung zone images.

FIGURE 7

Proportion of accurately interpreted lung point-of-care ultrasound (POCUS) images (%) from the final three scans performed by the respiratory therapists after completing the acquisition and retention of lung ultrasound skills by respiratory therapists POCUS curriculum. Upper lung zones: anterior chest wall and anterior axillary line. Lower lung zones: costophrenic angle and posterolateral alveolar pleural syndrome

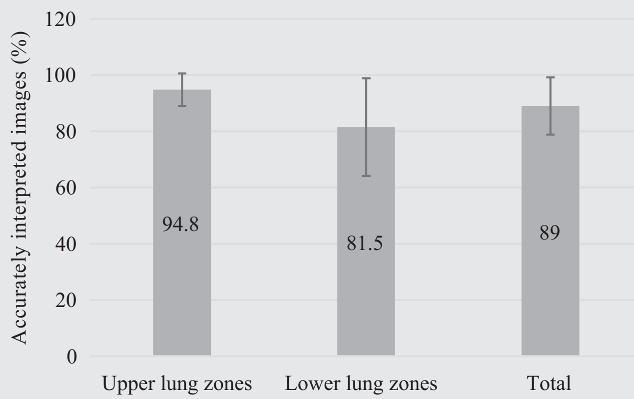
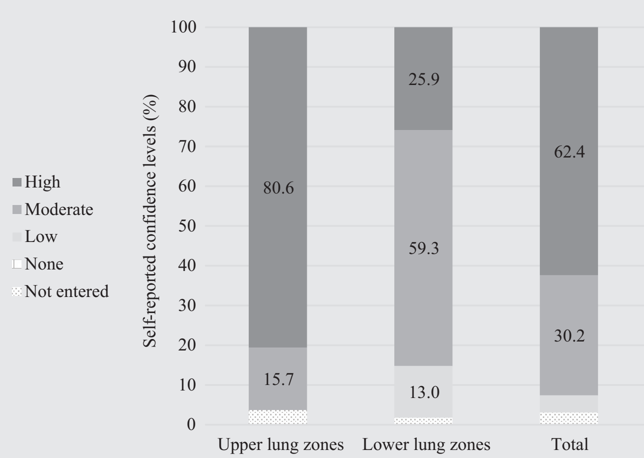


FIGURE 8

Proportion of lung ultrasound scans (%) in which respiratory therapists self-reported high, moderate, low, no confidence or when they did not report their confidence level in the final three scans. Upper lung zones: anterior chest wall and anterior axillary line. Lower lung zones: costophrenic angle and posterolateral alveolar pleural syndrome



Barriers to learning lung POCUS identified by the RTs included busy shifts lacking in sufficient time to scan patients and poor access to appropriate patients to scan (eg, patients hemodynamically unstable, patients leaving the unit for a test, patients sleeping, etc.). A minority of RTs also commented that they would have appreciated receiving feedback in real-time and in-person, rather than through the Qpath software.

DISCUSSION

The RTs achieved and maintained competence in acquiring and interpreting upper lung zone ultrasound images as well as competence in acquiring lower lung zone images after completing the A-LURT intervention. They did not initially achieve competence in interpreting lower lung zone images after completing 10 scans but did so after completing a further 3 scans in the follow-up evaluation period. We noted that the RTs were better able to acquire and interpret upper lung zone images compared with lower lung zone images throughout the study, and they were also more confident in their upper lung zone image acquisition and interpretation compared with their lower lung zone images. This is in keeping with what has been observed at our centre when resident physician trainees perform lung POCUS. This is likely related to the challenges associated with obtaining lower lung zone ultrasound images in immobile, non-cooperative and often obese patients.

Importantly, it was noted that many of the errors in interpretation of the lower lung zone images were unlikely to be of high clinical significance. More frequent errors were failure to note a small compressive consolidation in the presence of a large pleural effusion or failure to note a trace pleural effusion in the presence of a large consolidation.

FIGURE 9

Confidence and accuracy relationship (final three scans)

	Confidence	
Accuracy	**High/moderate (%)**	**Low/none (%)**
Accurate	85.8	50
Inaccurate	14.2	50

	High	Moderate
Inaccurate	4.1%	10.1%

This is reassuring, as this would make it unlikely that the patient would suffer harm because of an inappropriate intervention or missed diagnosis if RTs were to incorporate lung POCUS into their daily practice.

Another important finding that we noted was that when the RTs were confident in their images and interpretations, they frequently interpreted their images accurately. During the time they were completing their first 10 scans, the RTs demonstrated a higher degree of underconfidence; 10.6% of the time they reported feeling low or no confidence in their images and interpretations and yet their images and interpretations were accurate. This decreased to 2.5% of the time during the follow-up period where they completed three final scans. Encouragingly, we saw minimal levels of overconfidence. During both phases of this project, RTs demonstrated at least some degree of doubt (by rating their confidence level as moderate or lower) when they ultimately inaccurately interpreted an image, in all but 3.0% and 3.7% of cases in the initial and final phases of the present study, respectively. These numbers were skewed by one RT in the initial phase and two different RTs in the final phase who demonstrated higher degrees of overconfidence compared with the mean. It was reassuring to see minimal overconfidence as this would reduce the risk of harm to patients, but these results did underscore the need for oversight of RTs performing lung POCUS at this stage of training.

The questionnaire completed by the RTs after all required lung ultrasounds were completed provided some excellent feedback regarding the A-LURT curriculum. The online didactic videos and practical sessions were generally felt to be quite helpful in learning lung POCUS. Notably, after completing 13 scans, a somewhat high proportion of participants did not feel competent to obtain and interpret lower lung zone images. The ‘Canadian recommendations for critical care ultrasound training and competence’ [20] would recommend 20 scans for intensivists and critical care trainees to achieve competency in lung ultrasound. Because of time and staffing constraints at our centre, it was not possible for the RTs to complete 20 lung ultrasound scans within the timeframe for the present study. Given that we observed an improvement in the RTs’ lung POCUS skills between 10 and 13 scans, we would expect that they would continue to improve and increase in confidence on completing, or shortly after completing, 20 lung POCUS studies.

Finally, other barriers identified by the RTs to completing the lung POCUS training and achieving competency were time constraints during their shifts and patient accessibility.

Strengths of the present study are that it is a blinded study; and the lung fields to be scanned, method of reporting interpretations and evaluations were standardized. Another strength is that in comparison to similar studies, we have studied new variables. For example, See et al [14] studied the changes in proportion of ultrasound scans requiring assistance from a supervisor and in proportions of correctly identified images as RTs completed higher numbers of scans. We also studied accuracy in image acquisition and interpretation, and our study is the first of its kind to investigate change in RTs’ self-reported confidence as well as whether competency was sustained after a 6-week follow-up period.

Weaknesses of our study include that a small sample size was used, and the number of lung ultrasounds performed by each RT was small. It is also possible that our sample is not representative of the general RT population because the RTs were not chosen randomly. This may have selected more highly motivated RTs. The fact that the RTs included in the present study had at least 5 years’ experience as a RRT, and that they were part of the critical care outreach team also selects for a group of RTs with more training and experience than the average RT. This may mean that our results would not be applicable to all RTs universally. RTs with less experience could require more or different training than this group of RTs. Also, the fact that the RTs’ ultrasound scans were evaluated remotely rather than at the bedside is a limitation of the present study. This could possibly lead to selection or submission bias if the RTs did not submit images they were not confident about. This could also possibly lead to missed findings because an expert did not repeat a lung POCUS scan immediately after the RT to verify findings. The lack of evaluation of the RTs’ lung POCUS skills before completing our training is also a weakness of the present study. An evaluation of the level of the RTs’ lung POCUS skills would have served as a baseline to which we could have compared the RTs’ performance after the training. Another weakness was the fact that only two RTs completed studies during the interim period. One RT completed one extra study and had slight deterioration in image acquisition skills (100% interpretable scans initially and 94% on follow up) and slight improvement in image interpretation (95% accurate interpretation initially and 100% accurate interpretation on follow up). The second RT completed three extra studies and had improvement in image acquisition (90%, which improved to 100% on follow up) and image interpretation (80%, which improved to 95% on follow up). This may have skewed our results in favour of improvement of skills in the follow-up period; however, overall the majority of RTs skills improved in the follow-up period compared with the initial evaluation despite not completing studies in the interim period (see Appendix 6 [1] for individual RT results). Finally, our follow up was performed after a relatively short period. It is possible that skills were maintained because of 6 weeks being an insufficient amount of time for skill deterioration to occur.

Our goal is that, in the future, RTs at our institution will use lung POCUS as an extension of their routine assessments (comprising physical examination, blood gases and chest x-rays) of patients and be able to report lung ultrasound findings such as A lines, B lines, consolidations and pleural effusions to the interprofessional team to assist in clinical decision-making. This training would not be intended for RTs to make diagnoses or treatment decisions independently. Although the A-LURT curriculum has brought us closer to this goal, the evidence from the present study is likely not sufficient to support widespread adoption of our training and implementation of RT lung POCUS in our centre.

Next steps would be to repeat the present study with a higher number of RTs. It would also be useful to have a pre-training evaluation of the RTs’ lung POCUS skills, and to then have at least 20 lung ultrasound studies per RT completed post-training. Consideration could also be given to having a second practical training session and protected time outside of their regular shift assignments for RTs to complete the ultrasound scans. The present study could also be repeated with immediate in-person evaluation of the completed studies.

CONCLUSION

Our study builds on previous works that have investigated RTs' ability to acquire and interpret lung POCUS images. Ours is the first to study whether RTs can sustain competence 6 weeks after training and their self-reported confidence in these skills throughout their training. Our hypothesis was that after completing our training curriculum the participating RTs would become competent and sustain their competency in lung POCUS. The A-LURT study has demonstrated that after completing the A-LURT curriculum and 10 lung POCUS scans, RTs achieved competence in acquisition and interpretation of upper lung zone images as well as acquisition of lower lung zone images. The present study has also demonstrated that RTs retain their newly acquired knowledge and skills in lung POCUS 6 weeks after the initial curriculum completion, and improved and achieved competence in lower lung zone image interpretation. We also note that RTs reported a high degree of confidence in upper lung zone image acquisition and interpretation and a moderate degree of confidence in lower lung zone image acquisition and interpretation, and that this improved on follow up after 6 weeks. More experience in lung POCUS is likely required to become more competent and confident in lower lung zone image acquisition and interpretation initially.

DISCLOSURES

Acknowledgements

Dr Vincent Lau is acknowledged for his contributions in lung POCUS quality assurance throughout the present study, as well as the drafting of this manuscript. Erin Boyce is acknowledged for her contribution to this project in performing the literature search.

Contributors

AY developed the RT ultrasound curriculum and educational materials, carried out the statistical analysis and drafted the manuscript. DW assisted with RT ultrasound curriculum and educational materials development, data acquisition, and drafting the manuscript. FM performed RT ultrasound evaluation and quality assurance, and assisted with drafting the manuscript. DB developed the audiovisual educational material and assisted with drafting the manuscript. MS was the RT leader and representative and assisted with drafting the manuscript. RA lead the study concept and design and assisted with RT ultrasound curriculum and educational materials development, statistical analysis, and drafting the manuscript.

Funding

The present study did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Competing interests

All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no financial relationships with any organizations that might have an interest in the submitted work in the previous 3 years; no other relationships or activities that could appear to have influenced the submitted work.

Ethical approval

Informed consent was obtained from all participants. The Western University Health Sciences Research Ethics Board approved the study.

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