Using lung ultrasound changes to evaluate the response of recruitment maneuver in a patient recovering from coronavirus disease 2019 with acute respiratory distress syndrome

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Abstract: Lung ultrasound (LUS) is widely used in intensive care units because it provides timely information noninvasively. The use of LUS is recommended to minimize transfers in critically ill patients with coronavirus disease 2019 (COVID-19) during the pandemic. The clinical efficacies of bedside chest X-ray (CXR) and LUS have not been compared in these patients. Herein, we demonstrated serial LUS changes in a 75-year-old woman recovering from COVID-19 with acute respiratory distress syndrome (ARDS) in need of veno-venous extracorporeal membrane oxygenation support. LUS initially revealed extensive consolidation in the bilateral lower lung (BLL) fields with coalescent B-lines. While the patient recovered from ARDS, the findings gradually changed to discrete B-lines and small pleural consolidations. The LUS findings were more sensitive than those of the CXR in detecting re-expansion of the lungs by showing B-lines instead of consolidations in the BLL fields immediately after recruitment maneuver (RM). Compared with physiological parameters, LUS findings provided more precise information about the parts of the lungs that had been recruited by RM. Therefore, we encourage intensivists to extend their use of LUS in critically ill patients with COVID-19 and ARDS to acquire real-time information for a quick response and minimize the risk of viral transmission.

Keywords: Acute respiratory distress syndrome; COVID-19; Lung ultrasound

1. INTRODUCTION

Critically ill patients with coronavirus disease 2019 (COVID-19) account for approximately 5% of infected individuals.[1,2] The case fatality rate (CFR) may be >50% in elderly individuals and those with multiple comorbidities,[1–4] rendering it a great challenge during the pandemic. These patients are undoubtedly in need of comprehensive intensive care, but patient isolation in concern of viral transmission may limit the modalities commonly used in clinical settings, such as computed tomography (CT) or even auscultation.

Lung ultrasound (LUS) is a widely used tool in intensive care units (ICUs) because it provides timely information with the advantages of repeatability and noninvasiveness.[5,6] The use of bedside LUS is also recommended to monitor disease status, as well as to minimize transfers among critically ill patients with COVID-19.[7] Herein, we reported a serial change in LUS findings in a patient recovering from COVID-19 with severe acute respiratory distress syndrome (ARDS) and used LUS findings to evaluate the response of recruitment maneuver (RM), a procedure implemented to manage refractory hypoxemia in ARDS. Data were extracted from medical records after obtaining consent from the patient's family. The informed consent form was reviewed and approved by the institutional review board of Taipei Veterans General Hospital (VGHIRB No. 2020-03-005BC).

2. CASE REPORT

A 75-year-old Taiwanese woman had a history of hypertension, type 2 diabetes mellitus under medical control and breast cancer status post-left-sided modified radical mastectomy. She traveled to South America and Europe in February 2020 and returned to Taiwan in mid-March 2020. She developed a cough with low-grade fever 5 days later and was admitted to a local hospital with polymerase chain reaction (PCR)-confirmed positivity for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (day 1).

Ten days after admission, progressive respiratory distress occurred, and she received endotracheal tube intubation and mechanical ventilator (MV) support on day 11. She was then referred to our hospital for further intensive care, where septic shock and severe ARDS developed with a PaO_2/FiO_2 ratio of 96 mmHg (Table 1). Deep sedation and neuromuscular blocking

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Table 1

Patient events and clinical characteristics

Days after confirmed COVID-19 positivity	Day 11	Day 16	Day 21	Day 26	Day 31	Day 36	Day 41	Day 46
Events	RF s/p ETT + MV	ARDS s/p VV-ECMO On Day 13	RM (days 18–20) and TCZ (days 20–21)			ECMO Decannulation		Weaning ETT + MV on day 44
BT, °C	40.6	37.0	37.2	37.6	38.2	38.2	38.0	37.3
APACHE II score	22	23	24	31	28	27	20	11
FiO_2, %	100	40	40	50	40	40	30	25
PaO_2/FiO_2, mmHg	96	183	230	234	340	243	320	320
WBC, cells/μL	11 200	7700	6200	6500	4800	20 600	8400	8100
Lymphocyte, cells/μL	538	647	1029	1151	1128	1895	1327	1620
Lactate, mg/dL	46.9	15.3	12.5	23.8	13.8	17.7	19.4	22.3
CRP, mg/dL	11.61	7.59	1.66	0.29	0.12	0.08	0.05	<0.03
Procalcitonin, ng/mL	1.12	2.67	0.51	0.25	0.08	0.11	0.04	0.05
D-dimer, μg/mL	7.22	6.46	17.87	15.24	18.12	6.88	N/A	1.59
LDH, U/L	604	675	658	754	341	270	269	286
Ferritin, ng/mL	604	562	684	1436	413	494	398	335
CK, U/L	65	22	63	37	12	29	N/A	11
SARS-CoV-2 PCR Ct-value								
NP	28.01	N/A	30.86	33.16	N/A	27.15	ND	ND
Saliva	33.21	N/A	33.80	N/A	33.00	31.05	ND	ND
Tracheal aspirate	26.22	29.98	34.34	ND	N/A	ND	ND	ND
Sputum culture		*C albicans*			*S maltophilia*		*S maltophilia*	
Antibiotics	TZP/TEC	MEM/TEC/ANI	SFP/TEC/ANI	TGC/CL/ANI	LVX/ANI	MEM/TEC/LVX	LVX	CAZ

ANI = anidulafungin; APACHE = Acute Physiology And Chronic Health Evaluation; ARDS = acute respiratory distress syndrome; BT = body temperature; CAZ = ceftazidime; CK = creatine kinase; CL = colistin; COVID-19 = coronavirus disease 2019; Ct-value = cycle threshold value; CRP = C-reactive protein; ETT = endotracheal tube; LDH = lactate dehydrogenase; LVX = levofloxacin; MEM = meropenem; MV = mechanical ventilation; N/A = not available; ND = not detectable; NP = nasopharynx; PCR = polymerase chain reaction; RF = respiratory failure; RM = recruitment maneuver; SARS-CoV-2 = severe acute respiratory syndrome coronavirus 2; SFP = cefoperazone/sulbactam; TCZ = tocilizumab; TEC = teicoplanin; TGC = tigecycline; TZP = piperacillin/tazobactam; VV-ECMO = veno-venous extracorporeal membrane oxygenation; WBC = white blood cell.

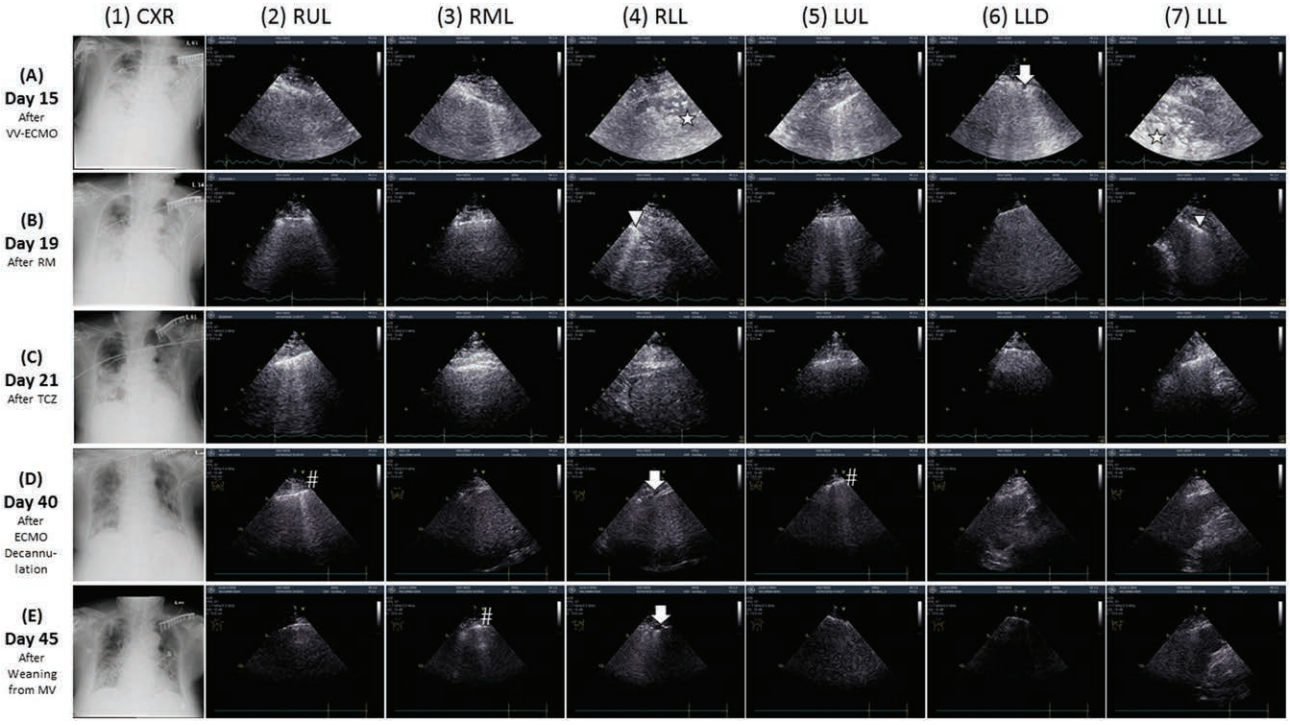

Fig. 1 Serial changes in CXR (panel 1) and LUS (panels 2–7) in a critically ill patient with COVID-19 on (A) day 15 after COVID-19 confirmation, ARDS with VV-ECMO support; (B) day 19, post-RM with an airway opening pressure of 45 cmH_2O; (C) day 21, after TCZ treatment with a total of 8 mg/kg in two divided doses; (D) day 40, 4 days after ECMO decannulation; and (E) day 45, 1 day after weaning from mechanical ventilation. Note that the basal lung consolidation (white asterisk) and coalescent B-lines (arrowhead) shown on LUS gradually changed to small pleural consolidations (arrow) and discrete B-lines (hashtag) or A-lines with normal lung sliding, with improvements in the clinical condition and CXR findings. ARDS = acute respiratory distress syndrome; COVID-19 = coronavirus disease 2019; CXR = chest X-ray; LLD = left lingular division of lung; LLL = left lower lung; LUL = left upper lung; LUS = lung ultrasound; RLL = right lower lung; RM = recruitment maneuver; RML = right middle lung; RUL = right upper lung; TCZ = tocilizumab; VV-ECMO = veno-venous extracorporeal membrane oxygenation.

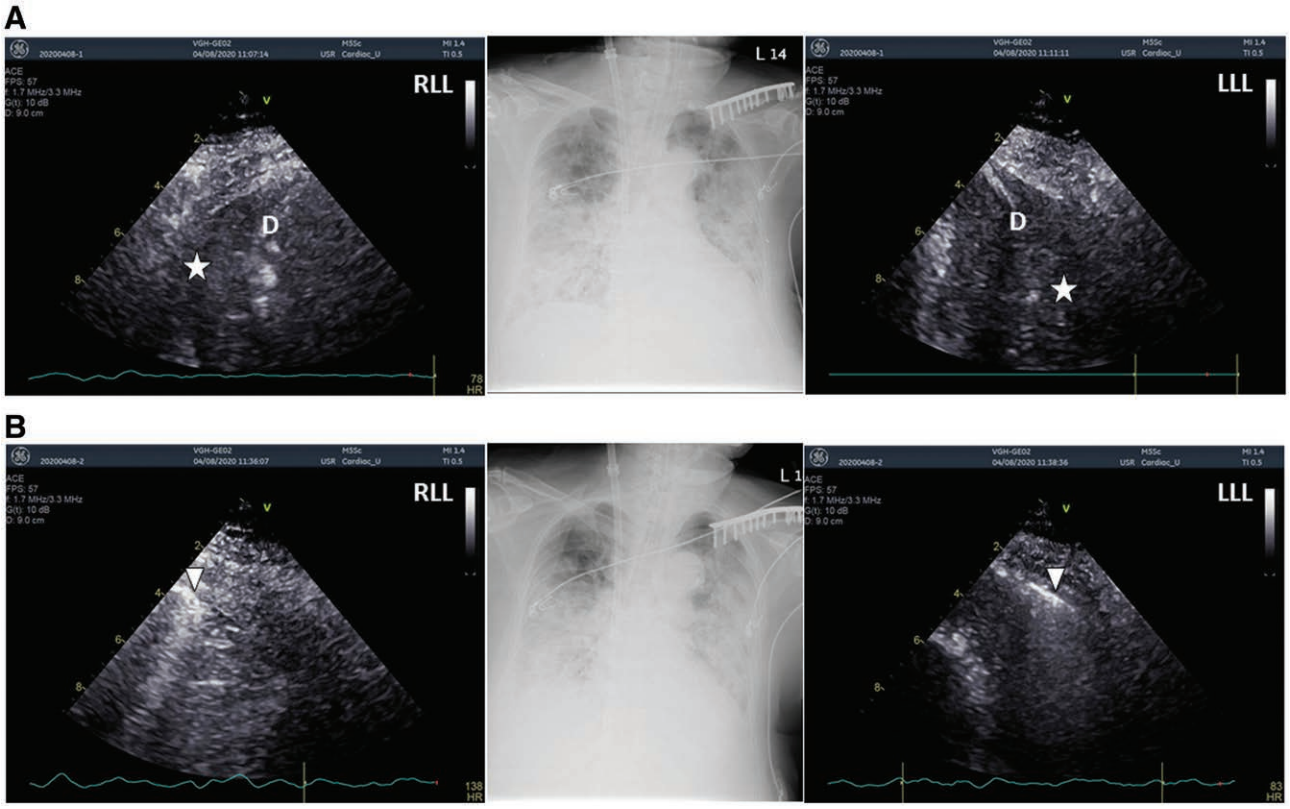

Fig. 2 Changes in LUS from (A) before the RM, showing consolidation (white asterisk) in the BLL fields, to (B) immediately after RM, return of lung sliding with B-lines (arrowhead) in the BLL fields. BLL = bilateral lower lung; D = diaphragm; LLL = left lower lung; LUS = lung ultrasound; RLL = right lower lung; RM = recruitment maneuver.

agents were used in combination with a protective ventilation strategy, but prone positioning was not performed because of her hemodynamic instability. Unfortunately, severe hypoxemia progressed; hence, veno-venous extracorporeal membrane oxygen (VV-ECMO) was applied on day 13.

Broad-spectrum antibiotics were administered for secondary bacterial and fungal infections and adjusted based on microbiological data from tracheal aspiration (Table 1). Hydroxychloroquine was administrated on days 11–20. For persistent hypoxemia, she received RM three times with an airway opening pressure of 40–45 cmH_2O on days 18–20. An elevated serum interleukin-6 (IL-6) level was noted; therefore, 8 mg/kg of tocilizumab (TCZ), a monoclonal antibody against IL-6 receptor, was administered on days 20–21. Her condition improved gradually, and VV-ECMO was decannulated on day 36 (total ECMO support duration: 24 days). The patient was successfully weaned from MV on day 44 (total MV support duration: 34 days) and discharged smoothly on day 75 after a few weeks of rehabilitation.

Imaging studies including chest X-ray (CXR) and LUS were performed serially. The LUS findings (Fig. 1) were classified anatomically into upper (panels 2 and 5), middle (panels 3 and 6), and lower (panels 4 and 7) lung fields. Initially, both CXR and LUS revealed extensive consolidation in the bilateral lower lung (BLL) fields (Fig. 1A, panel 1 and white asterisk in panels 4, and 7). Coalescent B-lines and small pleural consolidations (Fig. 1A, arrow) were also observed mainly in the bilateral upper and anterior areas (Fig. 1A; panels 3, 5, and 6). It is worth noting that while CXR before (Fig. 2A, middle panel) and after (Fig. 2B, middle panel) RM showed no significant changes in the BLL consolidations, LUS revealed the appearance of B-lines (Figs. 2B and 1B, arrowheads) instead of consolidations (Fig. 2A, white asterisks) in the BLL fields, indicating the re-expansion of the lungs and their potential recruitability. After TCZ treatment (Fig. 1C), the coalescent B-lines on LUS changed to discrete and multifocal with irregular pleura, which were compatible with improvement on CXR (Fig. 1C, panel 1). While the patient was successfully weaned from VV-ECMO (Fig. 1D) and MV (Fig. 1E), CXR showed greater improvement in the left lung field (Fig. 1D, E, panel 1) compared with LUS findings of discrete B-lines (Fig 1D, E, hashtag), small pleural consolidations (arrows), or A-lines with normal lung sliding (Fig. 1E, panels 5–7). Minimal subpleural consolidations on LUS were mainly found in the right lower lung (RLL) field, reflecting residual alveolar processes in the RLL shown on CXR.

3. DISCUSSION

This case demonstrated serial changes in LUS findings and revealed the lungs' recruitability after RM by applying these findings to a patient recovering from COVID-19 with ARDS. Bedside LUS notably provides real-time information to monitor disease progression and evaluate treatment response noninvasively.

In Taiwan, there were 429 confirmed cases of COVID-19 as of May 1, 2020 and a low overall CFR of 1.4%.[8] Nevertheless, 8.2% of patients were identified to have severe pneumonia or ARDS, including 5.6% who received MV and 1.6% in need of ECMO support. The CFR among patients receiving MV is 25%.[7] It remains a great challenge to manage critically ill patients with COVID-19.

While several compounds show potential in treating COVID-19, not a single drug is currently approved by the Food and Drug Administration.[1,9] Therefore, for patients who are critically ill,

optimal supportive care and close monitoring of disease status may be more important to overcome their critical condition.[1,10] Although chest CT is helpful in evaluating the extent of disease,[11] transfer from the ICU for CT scans poses a risk of viral transmission and might be dangerous in patients with hemodynamic instability. Therefore, bedside LUS is considered a reasonable surrogate for disease monitoring especially in critically ill patients with COVID-19.[7]

With deterioration in COVID-19-associated pneumonia, LUS findings change from irregular pleura and discrete B-lines in mild disease to coalescent B-lines and consolidations in critical cases.[12,13] Our patient who recovered from COVID-19 with ARDS demonstrated those findings in reverse order. Furthermore, LUS findings of bilateral, patchy distribution of multiple separated and coalescent B-lines, loss of lung sliding, small peripheral consolidations, and zones with irregular pleural line increased the probability of severe COVID-19, which is recommended for emergency department during the COVID-19 pandemic.[14]

While CXR can also be performed at the bedside, its clinical efficacy has not been compared with that of LUS in critically ill patients with COVID-19. Our case clearly demonstrated that LUS is more sensitive than CXR in detecting re-expansion of the lungs by showing B-lines instead of consolidations in the BLL fields immediately after RM, but the CXR findings remained similar between the procedures. Pan et al[15] recently evaluated the potential for lung recruitment in COVID-19 and ARDS using physiological parameters obtained from a ventilator, but the method does not reveal the parts of the lungs that have been recruited. In contrast, bedside LUS rapidly localizes and adequately estimates positive end-expiratory pressure–induced lung recruitment,[16] like that in our patient showing a return of B-lines from consolidations immediately after RM.

In conclusion, we encourage intensivists to extend their use of LUS in critically ill patients with COVID-19 and ARDS to acquire real-time information for quick responses and minimize the risk of SARS-CoV-2 transmission.

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