Section: Emergency Medicine

Original Research Article

DIAGNOSTIC UTILITY OF POINT-OF-CARE LUNG ULTRASOUND IN THE EVALUATION OF PATIENTS PRESENTING WITH ACUTE DYSPNEA TO THE EMERGENCY MEDICINE DEPARTMENT

Received : 24/07/2026
Received in revised form : 14/08/2026
Accepted : 27/08/2026

Keywords:
Lung ultrasound, BLUE protocol, dyspnea, emergency medicine department, point-of-care ultrasound, POCUS, HRCT.

Corresponding Author:
Dr. Boina Venkatesh,
Email: venkat31121991@gmail.com

DOI: 10.47009/jamp.2026.8.5.15

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2026; 8 (5); 90-95

Boina Venkatesh[1], Kanthala Santhosh Kumar[2], Thammineni Sruthi[3], Shirisha G[4] Kollikonda Mahendra Kumar[5], Sette Vijaya[6], Pranav Kumar[7]

[1,2,3,4]Assistant Professor, Department of Emergency Medicine, Mamata Medical College, Khammam, Telangana 507002, India.
[5]Professor and HOD, Department of Emergency Medicine, Mamata Medical College, Khammam, Telangana 507002, India.
[6,7]Junior Resident, Department of Emergency Medicine, Mamata Medical College, Khammam, Telangana 507002, India.

ABSTRACT

Background: Acute dyspnea is one of the most common reasons for presentation to the emergency medicine department, and rapid differentiation of its cause guides early treatment. Bedside lung ultrasound offers a radiation-free, repeatable method of assessment at the point-of-care. This study evaluated the diagnostic performance of point-of-care lung ultrasound, applied through the BLUE (Bedside Lung Ultrasound in Emergency) protocol, against high-resolution computed tomography (HRCT) in this population. **Materials and Methods:** This prospective observational study was conducted in the emergency department of a tertiary care hospital over 12 months. Three hundred patients older than 18 years presenting with shortness of breath underwent structured clinical assessment, point-of-care lung ultrasound, chest radiography, and HRCT. Sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of lung ultrasound were calculated against HRCT for six diagnostic categories: chronic obstructive pulmonary disease (COPD) or asthma exacerbation, pleural effusion, pneumonia, pulmonary edema, pneumothorax, and pulmonary thromboembolism. **Results:** The 59–68 year age group accounted for the largest share of patients (116, 38.7%), and 205 patients (68.3%) were male. Pulmonary edema was the leading diagnosis on clinical assessment, lung ultrasound, and HRCT alike. Compared with HRCT, lung ultrasound showed a sensitivity of 99.0% and specificity of 97.5% for pulmonary edema, 86.8% and 99.6% for pneumonia, 100% and 97.8% for pleural effusion, 83.3% and 100% for pneumothorax, 100% and 99.3% for pulmonary thromboembolism, and 100% and 92.5% for COPD or asthma exacerbation. Positive predictive value was lowest for COPD or asthma exacerbation (76.6%) and pleural effusion (78.6%). **Conclusion:** Point-of-Care Lung Ultrasound performed well across the common causes of shortness of breath seen in the emergency medicine department, missing no case of COPD or asthma exacerbation, pleural effusion, or pulmonary thromboembolism that HRCT confirmed. Its weakest point was a tendency to over-call COPD or asthma exacerbation, applied to 18 patients whose HRCT showed another diagnosis, three of them a pneumothorax. As a rapid, radiation-free bedside test that can be repeated without risk, lung ultrasound can support early triage decisions for patients presenting with acute dyspnea, provided a positive label of obstructive airway disease is confirmed clinically.

INTRODUCTION

Acute dyspnea is one of the most common symptoms leading to presentation at the emergency medicine department, and it remains frequent even among patients who are already admitted to hospital. In a large cohort assessed for dyspnea at the time of hospital admission, around one in ten patients reported the symptom as present on arrival, and it was more common among those with an underlying respiratory or cardiovascular diagnosis.[1] The causes of dyspnea range from common conditions such as asthma, chronic obstructive pulmonary disease (COPD), pneumonia, and heart failure to less common but serious diagnoses such as pulmonary embolism and pneumothorax. A systematic approach to distinguishing between these causes is essential to guide safe and timely treatment, since the management of one condition can worsen another if the working diagnosis is wrong. Because the differential diagnosis is broad and a missed or delayed diagnosis can have serious consequences, clinicians in the emergency medicine department need a way to narrow the possibilities quickly, ideally without moving the patient away from the resuscitation area or exposing them to additional risk.[2]

Clinical examination gives useful clues. Tachypnea, tachycardia, use of the accessory respiratory muscles, an inability to complete full sentences, and altered consciousness from hypercapnia all point to a patient who needs prompt evaluation. However, clinical signs alone often cannot separate one cause of dyspnea from another, particularly when a patient has more than one possible diagnosis, such as chronic lung disease with a superimposed episode of heart failure. Chest radiography is quick and widely available, but it has limited sensitivity for small pleural effusions, early pneumonia, and interstitial fluid. Computed tomography is more accurate but requires the patient to leave the resuscitation area, exposes them to ionising radiation, and is not always available immediately in a busy emergency medicine department. Blood tests such as arterial blood gas analysis and brain natriuretic peptide add useful supporting information, but results take time to return and do not, by themselves, localise the problem to a specific organ or region of the lung. A bedside test that gives an immediate, visual answer is therefore attractive in this setting. Point-of-Care Ultrasound (POCUS) has been proposed as a way to close this gap. It can be performed at the patient's bedside within minutes, gives an immediate answer, and can be repeated without any radiation risk. A comparison of lung ultrasound with bedside chest radiography in critically ill patients found that ultrasound detected more abnormalities and agreed better with the final diagnosis than radiography, particularly for pleural effusion and lung consolidation.[3] These findings support a wider role for ultrasound as a first-line bedside tool rather than only a research technique.

The technique relies on a small number of recognisable patterns. A normal, aerated lung produces horizontal A-lines and a sliding pleural line. When the lung interstitium becomes fluid-filled, as in pulmonary edema, vertical B-lines appear and multiply. Consolidated lung, as in pneumonia, looks similar to solid tissue and may show visible air bronchograms. Pleural effusion appears as an anechoic space above the diaphragm, and the absence of lung sliding, together with a lung point, indicates pneumothorax. Building on these signs, a structured bedside scanning protocol was described to guide the diagnosis of acute respiratory failure at the point of care, using a fixed sequence of scanning points on the anterior and lateral chest wall, together with a posterolateral point, on each side.[4] Combining the findings at these points into a small number of recognisable profiles separates cardiogenic pulmonary edema from an exacerbation of obstructive airway disease and from pneumonia, and a working diagnosis can usually be reached within minutes of starting the scan.

Lung ultrasound has also been examined for its role in pulmonary embolism. Although it cannot directly visualise a clot within the pulmonary artery, it can detect small, peripheral, wedge-shaped areas of infarction and an associated pleural effusion. A meta-analysis of the available diagnostic studies reported a useful level of accuracy for this indirect approach, particularly when the ultrasound findings were combined with clinical probability scoring.[5] It is also used to guide safe thoracentesis, by identifying the size of an effusion and marking a puncture site away from the diaphragm and adjacent organs, which reduces the risk of complications compared with a blind approach. These additional uses widen the range of conditions in which bedside ultrasound can support, rather than replace, the standard diagnostic pathway.

Most of the evidence supporting point-of-care lung ultrasound comes from high-income settings with established ultrasound training programmes. Its reported accuracy also varies between conditions: it performs consistently well for pleural effusion and pneumothorax but is more variable for distinguishing between different causes of a diffuse B-line pattern, and this variation needs to be defined locally rather than assumed from studies done elsewhere. Direct comparative data from Indian tertiary care emergency medicine departments, where HRCT often remains the reference standard for chest imaging, are limited. This study was conducted to determine the diagnostic performance of Point-of-Care Lung Ultrasound, applied through a structured scanning protocol, against HRCT in patients presenting with acute dyspnea to the emergency medicine department of a tertiary care hospital.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Emergency Medicine of a tertiary care teaching hospital in Telangana over a period of 12 months. The study protocol was approved by the institutional ethics committee, and written informed consent was obtained from every participant, or from a legally acceptable representative when the patient could not consent directly, before enrolment. Consecutive adult patients presenting to the emergency department with shortness of breath, and showing physical signs of respiratory distress such as tachypnea, tachycardia, use of the accessory respiratory muscles, an inability to speak in full sentences, or depressed consciousness

ISSN (O): 2687-5365; ISSN (P): 2753-6556

attributable to hypercapnia, were screened for eligibility. Three hundred patients who met the inclusion criteria were enrolled. Each enrolled patient first underwent a structured clinical assessment, recording respiratory rate, pulse rate, peripheral oxygen saturation, temperature, use of accessory respiratory muscles, and Glasgow Coma Scale score. Bedside lung ultrasound was then performed at the point-of-care by trained emergency medicine faculty, using a Samsung HS50 ultrasound machine, scanning seven fixed points across the anterior, lateral, and posterolateral chest wall. Findings were interpreted according to the BLUE protocol and included the presence or absence of lung sliding, the A-line and B-line pattern, the quad sign of pleural effusion, and the tissue-like and shred signs of consolidation. On this basis, each patient was assigned to one of six ultrasound diagnostic categories: COPD or asthma exacerbation, pneumonia, pleural effusion, pulmonary edema, pneumothorax, or pulmonary thromboembolism.

A bedside chest radiograph was obtained in every patient, using a ERAY SMART-5HS portable digital radiography machine, to look for consolidation, pleural effusion, pneumothorax, or pulmonary edema. HRCT of the chest, performed on a Siemens SOMATOM Scope CT scanner with or without contrast as clinically indicated, as the reference standard against which the accuracy of lung ultrasound was assessed. Sensitivity, specificity, positive predictive value, and negative predictive value of lung ultrasound were calculated for each of the six diagnostic categories using the corresponding HRCT diagnosis as the reference.

Data were entered and analysed using SPSS version 31.0 and Microsoft Excel for Microsoft 365. Continuous variables are expressed as mean and standard deviation, and categorical variables as frequency and percentage. Data are presented in tabular and graphical form.

Inclusion criteria

Age above 18 years

Presentation to the emergency medicine department with dyspnea

Willingness to provide written informed consent to participate

No prior definitive diagnosis established for the current episode of dyspnea

Exclusion criteria

Age below 18 years

Pregnant patients

Denial of consent to be part of the study.

RESULTS

Three hundred patients meeting the inclusion criteria were enrolled and completed clinical assessment, bedside lung ultrasound, chest radiography, and HRCT.

Most patients were in the 59–68 years age group, and men outnumbered women in every age group except in the group of 19-28 years. [Table 1]

Table 1: Age and gender distribution of the study population (n = 300)

Age group (years)	Male, n	Female, n	Total, n (%)
19–28	5	7	12 (4.0%)
29–38	12	6	18 (6.0%)
39–48	37	23	60 (20.0%)
49–58	73	21	94 (31.3%)
59–68	78	38	116 (38.7%)
Total	205 (68.3%)	95 (31.7%)	300 (100%)

On clinical assessment, pulmonary edema was the most common working diagnosis, followed by COPD or asthma exacerbation, while pulmonary thromboembolism was the least common. [Figure 1]

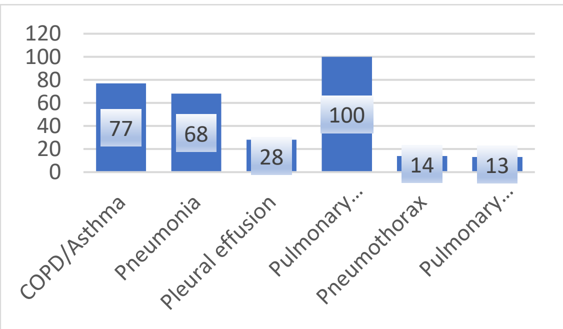

Figure 1: Clinical diagnosis based on history, examination, and vital signs in the study population (n = 300)

Bedside lung ultrasound diagnosis using the BLUE protocol closely matched the clinical diagnosis in the same population, with pulmonary edema again the most frequent finding. [Table 2]

ISSN (O): 2687-5365; ISSN (P): 2753-6556

Table 2: Bedside lung ultrasound diagnosis using the BLUE protocol in the study population (n = 300)

Lung ultrasound diagnosis	n	%
COPD or asthma exacerbation	77	25.7%
Pneumonia	67	22.3%
Pleural effusion	28	9.3%
Pulmonary edema	100	33.3%
Pneumothorax	15	5.0%
Pulmonary thromboembolism	13	4.3%

On HRCT, pulmonary edema remained the leading diagnosis. A small number of patients had findings outside the six primary diagnostic categories, including nine with a normal scan, four with pulmonary metastasis, three with an aspirated foreign body, and two with more than one coexisting diagnosis. [Table 3]

Table 3: HRCT diagnosis in the study population (n = 300)

HRCT diagnosis	n	%
COPD or asthma exacerbation	59	19.7%
Pneumonia	76	25.3%
Pleural effusion	22	7.3%
Pulmonary edema	96	32.0%
Pneumothorax	18	6.0%
Pulmonary thromboembolism	11	3.7%
Normal HRCT	9	3.0%
Foreign body aspiration	3	1.0%
Metastasis to lungs	4	1.3%
Mixed diagnosis	2	0.7%

Against HRCT, lung ultrasound identified every patient whose HRCT showed COPD or asthma exacerbation, giving a sensitivity of 100%, but it also applied that label to 18 patients whose HRCT showed another diagnosis, so specificity was 92.5% and positive predictive value 76.6%. For pleural effusion, sensitivity was also 100%, with a specificity of 97.8% and a positive predictive value of 78.6%. [Table 4]

Table 4: Diagnostic performance of bedside lung ultrasound (USG) compared with HRCT for COPD/asthma exacerbation and pleural effusion. PPV: positive predictive value; NPV: negative predictive value

Diagnosis	USG positive, n	HRCT positive, n	Sensitivity, %	Specificity, %	PPV, % / NPV, %
COPD or asthma exacerbation	77	59	100.0	92.5	76.6 / 100
Pleural effusion	28	22	100.0	97.8	78.6 / 100

Sensitivity for pneumonia was 86.8%, with a specificity of 99.6%; the ten patients with pneumonia on HRCT that ultrasound did not label as such were reported as pleural effusion in five cases and pulmonary edema in five. For pulmonary edema, sensitivity was 99.0% and specificity was 97.5%. [Table 5]

Table 5: Diagnostic performance of bedside lung ultrasound compared with HRCT for pneumonia and pulmonary edema

Diagnosis	USG positive, n	HRCT positive, n	Sensitivity, %	Specificity, %	PPV, % / NPV, %
Pneumonia	67	76	86.8	99.6	98.5 / 95.7
Pulmonary edema	100	96	99.0	97.5	95.0 / 99.5

For pneumothorax, lung ultrasound had a sensitivity of 83.3% and specificity of 100%; the three missed cases were all reported as COPD or asthma exacerbation. For pulmonary thromboembolism, sensitivity was 100% with a specificity of 99.3%. [Table 6]

Table 6: Diagnostic performance of bedside lung ultrasound compared with HRCT for pneumothorax and pulmonary thromboembolism

Diagnosis	USG positive, n	HRCT positive, n	Sensitivity, %	Specificity, %	PPV, % / NPV, %
Pneumothorax	15	18	83.3	100	100 / 98.9
Pulmonary thromboembolism	13	11	100.0	99.3	84.6 / 100

Clinical diagnosis and lung ultrasound diagnosis matched closely for most conditions, with the

ISSN (O): 2687-5365; ISSN (P): 2753-6556

smallest agreement seen for pneumonia and complete agreement for pulmonary edema, pleural effusion, and pulmonary thromboembolism. [Table 7]

Table 7: Concordance between clinical diagnosis and bedside lung ultrasound diagnosis in the study population (n = 300 for each)

Diagnosis	Clinical diagnosis, n	Lung USG diagnosis, n	Concordance, %
COPD or asthma exacerbation	77	77	100.0
Pneumonia	68	67	98.5
Pleural effusion	28	28	100.0
Pulmonary edema	100	100	100.0
Pneumothorax	14	15	93.3
Pulmonary thromboembolism	13	13	100.0

Across the six diagnostic categories, sensitivity ranged from 83.3% for pneumothorax to 100% for COPD or asthma exacerbation, pleural effusion, and pulmonary thromboembolism, and specificity from 92.5% to 100%. The errors were concentrated in two places: 18 patients labelled as COPD or asthma exacerbation had a different diagnosis on HRCT, and 10 patients with pneumonia on HRCT were labelled as pleural effusion or pulmonary edema.

DISCUSSION

In this cohort of 300 patients presenting with acute dyspnea, Point-of-Care Ultrasound had a sensitivity of at least 83.3% and a specificity of at least 92.5% for all six diagnostic categories when checked against HRCT. The lowest sensitivity, 83.3%, was for pneumothorax, and the lowest positive predictive value, 76.6%, was for COPD or asthma exacerbation, the category ultrasound most often over-called. This pattern is consistent with previous point-of-care lung ultrasound studies in dyspneic patients.

For pulmonary edema, our sensitivity of 99.0% is above the pooled estimate reported by Al Deeb et al,[6] who combined data from several studies of point-of-care ultrasound in patients with acute dyspnea and found a pooled sensitivity above 85% for B-line detection in acute cardiogenic pulmonary edema. Our specificity of 97.5% was also in keeping with that analysis. All five false-positive edema readings were in patients whose HRCT showed pneumonia, reflecting the overlap between the B-line pattern of cardiogenic edema and the interstitial change that can surround a consolidation.

Our sensitivity of 86.8% for pneumonia is comparable with the accuracy reported by Cortellaro et al,[7] who found that lung ultrasound performed in the emergency department identified pneumonia more often than chest radiography when both were checked against a composite reference diagnosis. Our specificity of 99.6% was higher than in their series, which may reflect differences in case mix, since HRCT, our reference standard, is more sensitive for small consolidations than the chest-radiography-based reference used in some earlier series. The ten pneumonias that ultrasound did not identify were labelled instead as pleural effusion or pulmonary edema, both of which share sonographic features with a consolidated, partly fluid-filled lung.

The overall pattern of our findings, strong for pleural effusion, consolidation, and pneumothorax, with the residual errors clustering wherever two diagnoses shared a B-line or consolidation pattern, mirrors the summary given in international consensus recommendations on point-of-care lung ultrasound.[8] Those recommendations note that a diffuse B-line pattern can arise from several different conditions and should be interpreted alongside the clinical picture rather than in isolation. This distinction matters in practice: every false-positive reading of pulmonary edema in our cohort was a patient with pneumonia on HRCT, in whom diuretic treatment rather than antibiotics would have been the wrong first step.

Our sensitivity and specificity for pneumothorax, 83.3% and 100%, sit within the range described by Lichtenstein et al,[9] who assessed lung sliding, the A-line sign, and the lung point in critically ill patients and found that this combination of signs identified radio-occult pneumothorax missed on supine chest radiography. Our slightly lower sensitivity may reflect that our patients were less critically unwell overall, and a small pneumothorax on HRCT may not always produce a detectable loss of lung sliding at the fixed scanning points used. All three missed pneumothoraces were labelled as COPD or asthma exacerbation, a reminder that a wheezy chest does not exclude the diagnosis.

For pulmonary thromboembolism, ultrasound identified all eleven patients whose HRCT confirmed the diagnosis, and labelled two further patients as thromboembolism whose HRCT was normal, giving a positive predictive value of 84.6%. This is similar to the accuracy reported by Mathis et al,[10] who examined thoracic ultrasound findings, principally peripheral wedge-shaped consolidations, in a large multicentre cohort and found a comparable level of accuracy when ultrasound was combined with clinical assessment. As in their study, ultrasound in our patients could not directly visualise a central clot and relied on secondary pleural-based signs together with detection of deep vein thrombosis in the leg veins, so this result should not be read as a licence to exclude the diagnosis on ultrasound alone.

The B-line count used in our protocol to identify pulmonary edema follows the approach validated by Bedetti et al,[11] who showed that ultrasound lung comets could be identified reliably even with simplified, hand-held equipment. This supports the feasibility of the sign in a busy emergency medicine department where a full-featured ultrasound machine is not always at hand.

Our overall diagnostic accuracy is in keeping with a tertiary care series from northern India reported by Baid et al,[12] who prospectively enrolled patients with acute dyspnea and found good agreement between point-of-care ultrasound and the final composite diagnosis reached by emergency physicians, with high sensitivity for pulmonary edema, pleural effusion, and pneumonia. Their study, like ours, was conducted in a setting where lung ultrasound offers a practical alternative to early computed tomography for most patients.

Beyond diagnostic accuracy alone, ultrasound changes how quickly a working diagnosis is reached. Umuhire et al,[13] found that adding ultrasound to the standard work-up in a Rwandan emergency department changed the leading diagnosis in two-thirds of dyspneic patients and markedly improved diagnostic accuracy for conditions such as heart failure and pneumonia. Gaber et al,[14] reported that a standardised ultrasound approach reached a diagnosis with accuracy similar to standard care but in a fraction of the time, a median of 12 minutes compared with 270 minutes. This supports lung ultrasound as a tool that shortens the path to a working diagnosis without a loss of accuracy.

Distinguishing pulmonary edema from other causes of diffuse lung infiltration remains a recognised limitation of ultrasound. Copetti et al,[15] compared chest sonography findings in patients with acute cardiogenic pulmonary edema against those with acute respiratory distress syndrome and showed that additional signs, including spared areas of normal lung and pleural line abnormalities, can help separate the two conditions, an approach that may have prevented some of the false-positive edema readings in our cohort.

Our study has limitations. It was conducted at a single centre, the six diagnostic categories were treated as mutually exclusive so that patients with coexisting diagnoses could not be fully represented, a minority of HRCT findings fell outside those categories, and ultrasound was performed by trained emergency medicine faculty whose results may not generalise to less experienced operators. Despite these limitations, the findings support Point-of-Care Ultrasound as a practical addition to the initial assessment of acute dyspnea in the emergency medicine department.

CONCLUSION

Point-of-Care Lung Ultrasound, applied through a structured scanning protocol, showed good agreement with HRCT across the common causes of acute dyspnea in the emergency medicine department, with a sensitivity of at least 83.3% and a specificity of at least 92.5% in every diagnostic category. Its main weakness in practice was over-calling COPD or asthma exacerbation, where roughly one in four positive ultrasound labels proved to be another diagnosis on HRCT, including three pneumothoraces, so clinical assessment remains necessary alongside ultrasound for that group. As a rapid, radiation-free, repeatable bedside test, point-of-care lung ultrasound can help emergency medicine faculty and residents reach an early working diagnosis and start appropriate treatment sooner, particularly when computed tomography is not immediately available.

REFERENCES

1. Stevens JP, Dechen T, Schwartzstein R, et al. Prevalence of dyspnea among hospitalized patients at the time of admission. J Pain Symptom Manage. 2018;56(1):15-22. doi:10.1016/j.jpainsymman.2018.02.013.
2. Berliner D, Schneider N, Welte T, Bauersachs J. The differential diagnosis of dyspnea. Dtsch Arztebl Int. 2016;113(49):834-845. doi:10.3238/arztebl.2016.0834
3. Xirouchaki N, Magkanas E, Vaporidi K, et al. Lung ultrasound in critically ill patients: comparison with bedside chest radiography. Intensive Care Med. 2011;37(9):1488-1493. doi:10.1007/s00134-011-2317-y
4. Lichtenstein DA, Mezière GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol. Chest. 2008;134(1):117-125. doi:10.1378/chest.07-2800
5. Squizzato A, Rancan E, Dentali F, et al. Diagnostic accuracy of lung ultrasound for pulmonary embolism: a systematic review and meta-analysis. J Thromb Haemost. 2013;11(7):1269-1278. doi:10.1111/jth.12232
6. Al Deeb M, Barbic S, Featherstone R, Dankoff J, Barbic D. Point-of-care ultrasonography for the diagnosis of acute cardiogenic pulmonary edema in patients presenting with acute dyspnea: a systematic review and meta-analysis. Acad Emerg Med. 2014;21(8):843-852. doi:10.1111/acem.12435
7. Cortellaro F, Colombo S, Coen D, Duca PG. Lung ultrasound is an accurate diagnostic tool for the diagnosis of pneumonia in the emergency department. Emerg Med J. 2012;29(1):19-23. doi:10.1136/emj.2010.101584
8. Volpicelli G, Elbarbary M, Blaivas M, et al. International evidence-based recommendations for point-of-care lung ultrasound. Intensive Care Med. 2012;38(4):577-591. doi:10.1007/s00134-012-2513-4
9. Lichtenstein D, Mezière G, Lascols N, et al. Ultrasound diagnosis of occult pneumothorax. Crit Care Med. 2005;33(6):1231-1238. doi:10.1097/01.ccm.0000164542.86954.b4
10. Mathis G, Blank W, Reissig A, et al. Thoracic ultrasound for diagnosing pulmonary embolism: a prospective multicenter study of 352 patients. Chest. 2005;128(3):1531-1538. doi:10.1378/chest.128.3.1531
11. Bedetti G, Gargani L, Corbisiero A, Frassi F, Poggianti E, Mottola G. Evaluation of ultrasound lung comets by hand-held echocardiography. Cardiovasc Ultrasound. 2006;4:34. doi:10.1186/1476-7120-4-34
12. Baid H, Vempalli N, Kumar S, et al. Point of care ultrasound as initial diagnostic tool in acute dyspnea patients in the emergency department of a tertiary care center: diagnostic accuracy study. Int J Emerg Med. 2022;15(1):27. doi:10.1186/s12245-022-00430-8
13. Umuhire OF, Henry MB, Levine AC, Cattermole GN, Henwood P. Impact of ultrasound on management for dyspnea presentations in a Rwandan emergency department. Ultrasound J. 2019;11(1):18. doi:10.1186/s13089-019-0133-8
14. Gaber HR, Mahmoud MI, Carnell J, et al. Diagnostic accuracy and temporal impact of ultrasound in patients with dyspnea admitted to the emergency department. Clin Exp Emerg Med. 2019;6(3):226-234. doi:10.15441/ceem.18.072
15. Copetti R, Soldati G, Copetti P. Chest sonography: a useful tool to differentiate acute cardiogenic pulmonary edema from acute respiratory distress syndrome. Cardiovasc Ultrasound. 2008;6:16. doi:10.1186/1476-7120-6-16.