Study of Point of Care Lung Ultrasound in Patients with Acute Respiratory Failure

Niraj Puri[1], Shital Adhikari[1], Madhur Dev Bhattarai[1], Basanta Gauli[1], Sailesh Gurung[1], Sunil Patel[1], Pratik Wagley[1]

[1]Department of Pulmonary and Critical Care Medicine, Chitwan Medical College Teaching Hospital, Bharatpur, Nepal

ABSTRACT

Introduction: An acute dyspnea has been a common cause of hospital admission throughout history. When formulating a treatment plan based on limited clinical information, a rapid diagnosis is important. Bedside maneuvers and tests that deliver rapid and reliable results represent a cornerstone of diagnostics medicine.

Methods: This was a one-year cross-sectional research conducted at Chitwan Medical College Teaching Hospital. Consecutive patients with acute dyspnea whom were admitted for ≤ 6 hours were included in the study. A 5MHz micro-convex probe was used as the optimal single probe. Data entry and descriptive analysis were done in IBM SPSS version 20.0. Point estimate at 95% confidence interval was calculated along with frequency and descriptive statics.

Results: Pneumonia was the most common overall ultrasound diagnosis with combined frequency of 47%. With a Positive Predictive Value of 94.11% and Negative Predictive Value of 97.01%, anterior pneumonia exhibited a sensitivity of 94.11% and specificity of 97.11%. Similarly, Posterior Lateral Alveolar Points (PLAPS) pneumonia had a sensitivity of 94.11% and specificity of 98.08%, with a PPV of 94.11% and NPV of 98.80% respectively. The clinical accuracy for pulmonary edema was the greatest with 96.77%. while COPD/asthma had least accuracy with 81.25%.

Conclusions: POCUS of the lung, has a high sensitivity and specificity, especially for evaluation of acute causes of dyspnea such pulmonary edema and pneumonia. It is more sensitive than Chest X ray alone and should be integrated while making clinical diagnosis.

Keywords: COPD/Asthma; Dyspnea; PLAPS; Pneumonia; POCUS

INTRODUCTION

Acute dyspnea has been a common cause of hospital admission throughout history,[1] especially with limited clinical information available. When formulating a treatment plan based on limited clinical information, a rapid diagnosis is very important.[2]

The chest CT scan is currently the gold standard diagnosing majority of lung pathology due to its higher sensitivity.[3] But it necessitates the transportation of a critically ill patient to the radiology department, which is not without danger. Furthermore, CT scanning comes at a high cost, emits a lot of radiation and may need contrast, so it is not something to take lightly.[4]

Bedside POCUS (Point Of Care Ultrasound) of lung can deliver rapid and reliable results which allows to distinguish between causes of acute dyspnea in minutes.[5] For many pulmonary diagnoses, POCUS is not only superior to the physical examination and chest X-ray, but also not inferior to CT scan.

METHOD:

This was a hospital based cross sectional study from August 2020 to August 2021. Ethical approval was taken from the Institutional Research Committee (IRC) of CMCTH, Ref no: 078/079-156. A total of 100 patients were included in the study. Consecutive admitted patients aged 18 and above who had an acute dyspnea as a major cause of hospital admission and were hospitalized for ≤ 6 hours at Chitwan Medical College and Teaching Hospital (CMCTH), under the Pulmonary and Critical Care Medicine department were included in the study. Exclusion criteria were current COVID-19 RT-PCR positive,

Corresponding author:
Niraj Puri
dr.nirajpuri@gmail.com

trauma causes, active pulmonary tuberculosis under less than 2 weeks of Anti Tuberculosis Treatment (ATT), Multi drug resistance (MDR)/extended drug resistance pulmonary tuberculosis (XDR), poisoning cases and pregnant patients. Also excluded from the study were patients who left early against medical advice or did not stay until the final diagnosis was confirmed.

Each patient (if awake) and their families were explained about of the stages and manner of POCUS of the lungs, and informed consent was signed. Each patient had a thorough history and physical examination taken, with the results being documented. All pertinent lab tests, radiography, ECG, and other investigations were collected for all patients. The symptoms of each condition were meticulously recorded, and the ultrasound data was then matched to the PCCM team's diagnosis. A 5MHz micro-convex probe was used as the optimal single probe for bedside POCUS of the lung. Patients were examined in supine position. And longitudinal transducer scans were performed. The Bed Lung Ultrasound Evaluation 'BLUE' protocol was used as the tool for POCUS of lung.[6] The procedure begins with a scan of the anterior "BLUE points". Identifying line artefacts is the initial step in our decision tree. As a result, the A and B-profiles may be separated. The A/B or C-profile is when one lung has A-predominance and the other has B-predominance. In the event of A or B profiles, the decision tree recommends further testing based on a combination of lung sliding, PLAPS results, lung point identification, and/or venous analysis. If there is any indication of alveolar consolidation or pleural effusion, PLAPS is considered positive. If an A-profile is present but no lung sliding, the lung point must be identified to establish the presence of pneumothorax. Starting from the BLUE point, where lung sliding was discovered to be missing, the operator advances the probe down the chest, keeping it in the same intercostal area, in quest of the lung point. Due to respiratory movement, the visceral pleura slides in and out of the ultrasound picture at this location on the thorax. As a result, M-mode imaging of the lung location will produce a pattern that alternates between the seashore and stratospheric signs.

Lower limb venous analysis was performed if there was A-lines with lung sliding. In this case, the presence of thrombus in the major veins of the lower leg clearly favours pulmonary embolism as the ultimate diagnosis. The femoral vein can be used to identify thrombus from patent veins with subtle compression motions. The presence of lung sliding and bilateral A-lines, but no evidence of PLAPS, for example, leads to a POCUS diagnosis of COPD/asthma exacerbation.

The following profiles were assigned:

- A-profile: Anterior predominant bilateral A lines (± ≤ 2 B-lines) associated with lung sliding
- A'-profile: A-profile (± ≤ 2 B-lines) with abolished lung sliding and without lung point
- B-profile: Anterior predominant bilateral B+ lines (≥3 lines) associated with lung sliding
- B'-profile: B-profile (≥3 lines) with abolished lung sliding
- A/B or C-profile: Anterior predominant B+ lines on one side, predominant A lines on the other side or anterior consolidation profile with mid-lung parenchyma B-profile
- PLAPS profile: Consolidation and/or pleural effusion
- Normal profile: A-profile without PLAPS

Data was collected using a Microsoft Excel spreadsheet, and statistical analysis was done using IBM SPSS version 20.0. Quantitative variables were reported as mean (SD) or median, whereas categorical variables were expressed as frequency (percentages) (IQR). Standard formulae were used to compute sensitivity, specificity, and positive and negative predictive values. A p-value of less than 0.05 was deemed significant. As the numbers of subjects compared were small, a non-parametric test (Kruskal-Wallis test) was carried out when ever needed. We employed Cox regression analyses using a time-dependent variable in this study, however we considered POCUS as a categorical variable characterized by distinct timings of lung POCUS rather than a binary variable.

RESULTS:

Table 1 shows the baseline characteristics of all 100 acute dyspneic patients. The patients were on average 59.6 years old, where 58% were females and 42% were males. Their mean BMI was 25.5, The heart rate was 105 beats per minute, MAP was 71.9 mm of Hg, respiratory rate was 28.1/min and the mean temperature was 98.1* F. Also, mean Spo2 was 91.7%. Comorbidities were present in 60% of all patients, with pulmonary and cardiac comorbidities being the most common. Cardiovascular comorbidity was present in 26%, pulmonary comorbidity in 22%, and renal comorbidity in 12% of the cases. Rather than being a single complaint, patients had a number of them. Fever (74%) was the most common symptom, followed by cough (64%), and chest pain (48%), pedal edema (30%), palpitations (20%), and impaired mental state (13%). In 66% of patients, the initial chest x-ray was abnormal. For the admitting clinical diagnosis 55% were diagnosed with anterior pneumonia, 21% with COPD/Asthma exacerbation, 13% with pulmonary edema, 7% with PLAPS pneumonia, and 5% with pneumothorax.

Table 2 shows the statistical diagnostic accuracy of POCUS of the lung with the final diagnosis. A pneumothorax diagnosis was confirmed in 8% of the patients. With a PPV of 100% and NVP of 98.92%, POCUS of the lung was 88.88% sensitive and 100% specific for pneumothorax. POCUS of the lung

exhibited a sensitivity of 96.85% and specificity of 98.55%, with a PPV of 96.87% and NPV of 98.55% for pulmonary edema. With a PPV of 94.11% and NPV of 97.01%, anterior pneumonia exhibited a sensitivity of 94.11% and specificity of 97.11%. Similarly, PLAPS pneumonia had a sensitivity of 94.11% and specificity of 98.08%, with a PPV of 94.11% and NPV of 98.80% and a PPV of 94.11% and NPV of 98.80%, respectively. Finally, COPD/asthma POCUS of lung statistical analysis showed sensitivity of 81.25%, specificity of 96.47%, PPV of 81.25%, and NPV of 96.47%.

Table 3 compares the clinical accuracy of the Final diagnosis with the POCUS of lung diagnosis. The clinical accuracy for pulmonary edema was the greatest, at 96.77%. With 94.11%, PLAPS pneumonia and/or pleural effusion came in second, followed by anterior pneumonia with 93.75%. When compared to other diagnoses, the clinical accuracy of pneumothorax and COPD/asthma was low in our research. Pneumothorax diagnosis accuracy was 87.5%, while COPD/asthma diagnosis accuracy was 81.25%. However, the overall average clinical accuracy for POCUS of lung diagnosis for acute dyspnea among the 100 participants in our study was 90.67%, which is consistent with previous researches published.

DISCUSSION:

Our study findings are consistent with physio-pathologic patterns that have been in clinical usage since 1994, particularly as reflected by lung ultrasonography artifacts.[7] Acute dyspnea was linked to cardiac or pulmonary co-morbidities in around half of the patients. The cardinal indications of pneumonia, such as fever, cough, and chest discomfort, were present in the great majority of our patients, pointing to pneumonia as a cause of acute dyspnea than alternative explanations. The chest x-ray is a single shot 2D picture of the chest that, depending on the stage and location of the disease, may not always provide visual clarity of the lung disease. As a result, in our study, 1/3rd of the chest x-rays were normal. There was no diagnosis of pulmonary embolism in our study. Previous research suggests that deep venous thrombosis has a strong positive predictive value when combined with the A-profile, indicating that the search for venous thrombosis should be combined with lung examination.[8] POCUS of lung clinical accuracy was reported to be highest for pulmonary edema and pneumonia, and lowest for COPD/asthma in a subgroup study of POCUS of lung diagnosis versus final diagnosis. However, indications of pulmonary edema shown on CXR are known to take longer to resolve.[9] It's possible that POCUS findings are more responsive to dynamic changes in volume status. The accuracy of POCUS for pulmonary edema in our study might be even greater, as it could be linked to the resolution of diuretics given before POCUS testing. In a nutshell, ultrasonography revealed the differences between pneumonia and pulmonary edema. If supported by more evidence, this might be a useful tool for distinguishing cardiac from permeability-related pulmonary edema.

Knowing that the research sample was small, we chose this methodologic approach to promote internal validity above statistical power. Despite this tradeoff, the examination of these data shows that POCUS has greater clinical sensitivity in the identification of pulmonary edema and pneumonia when compared to clinical diagnosis. When a patient cannot be transported to the radiology department or has a budgetary constraint, lung ultrasonography saves time and reduces the necessity for a chest CT scan. In identifying most pulmonary problems, lung ultrasonography is essentially similar to chest CT, and it may be repeated as needed to offer extra information.[10] POCUS of Lung may look complicated at first glance, yet all it takes is a shift in mindset and practice.

CONCLUSION:

Our findings show that POCUS of the lung has a high sensitivity and specificity, notably for life-threatening acute causes of dyspnea including pulmonary edema and pneumothorax, which may be quickly corrected to some extent if diagnosed early. It's also more clinically sensitive than CXR for aiding clinical diagnosis as proved by our research. The overall accuracy of 90.67% is more than respectable to consider it as one of the important rapid diagnostic tool.

LEGENDS:

Tables:

Table 1: Baselines characteristics of all acute dyspneic patients

CHARACTERISTICS	FREQUENCY (n) = 100
Age (Mean)	59.6
Male	42%
Female	58%
Body Mass Index (Mean)	25.5
VITALS	
MAP- mm Hg (Mean)	71.9
Heart Rate/Min (Mean)	105
Respiration Rate/Min (Mean)	28.1
Temperature (*F)	98.9
Spo2 (%)	91.7
COMORBIDITIES	60%
Pulmonary	22%
Cardiac	26%
Renal	12%
PRESENTING SYMPTOM	
Chest pain	48%
Fever	74%
Cough	64%
Palpitation	20%
Pedal edema	30%
Altered mental status	13 %
CHEST X RAY	
Normal	34%
Abnormal	66%
CLINICAL DIAGNOSIS	
Pneumothorax	5%
Pulmonary edema	12%
Anterior Pneumonia	55%
PLAPS pneumonia	7%
COPD/asthma	21%

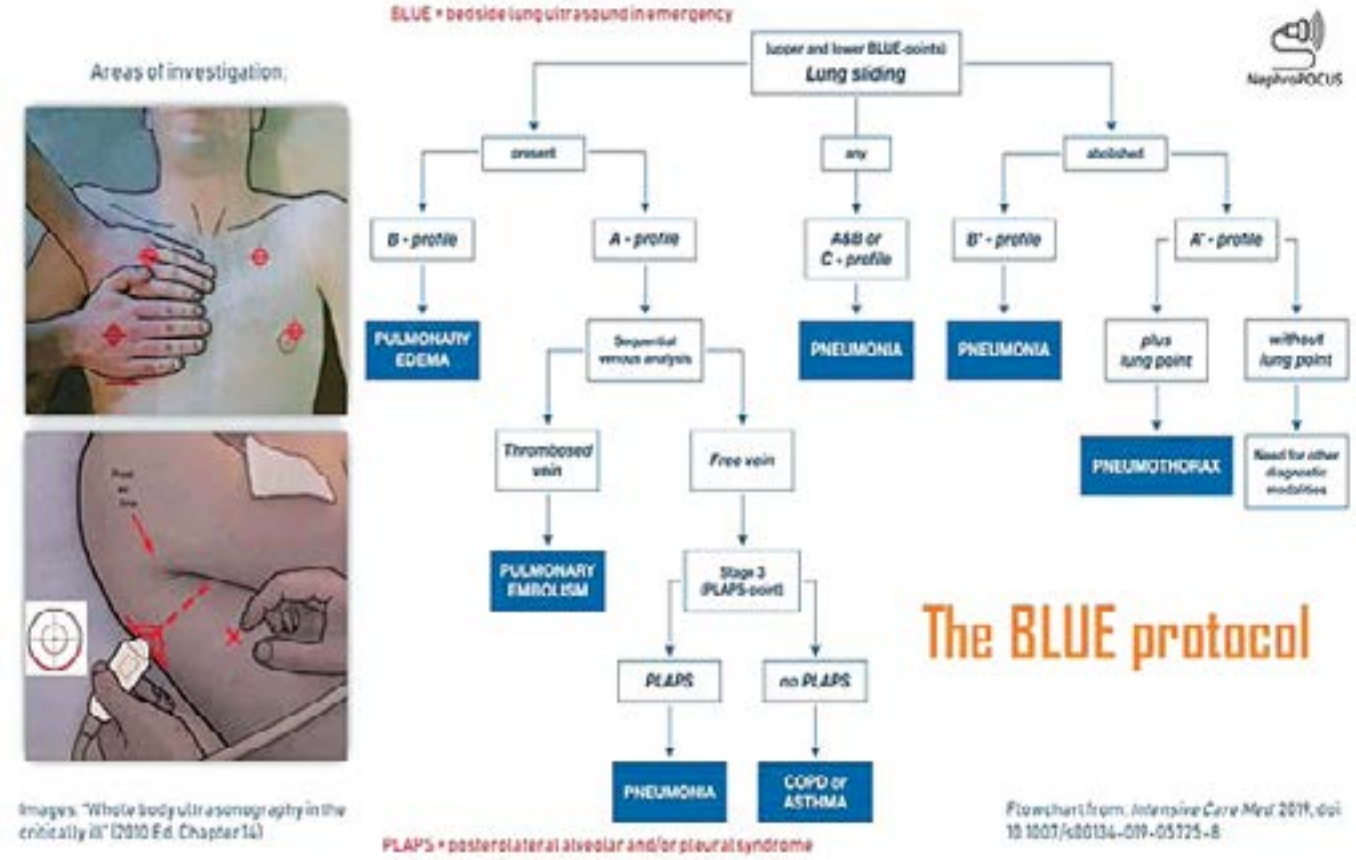
Table 2: Statistical diagnostic accuracy of POCUS of lung profiles

Final diagnosis	POCUS profile	Sensitivity	Specificity	Positive predictive value (PPV)	Negative predictive value (NPV)
Pneumothorax n=8	Absent anterior lung sliding and B lines, with or without lung point	88.88%	100%	100%	98.92%
Pulmonary edema n=31	Diffuse anterior B lines with lung sliding (B profile)	96.85%	98.55%	96.87%	98.55%
Anterior Pneumonia n=32	Bilateral B lines with abolished lung sliding (B' profile) or Anterior B lines on one side and A lines on another (A/B or C Profile)	94.11%	97.11%	94.11%	97.01%
PLAPS pneumonia n=16	PLAPS profile	94.11%	98.80%	94.11%	98.80%
COPD/asthma n=13	Predominant anterior A lines with lung sliding without PLAPS (Normal Profile)	81.25%	96.47%	81.25%	96.47%

Table 3: Clinical accuracy Comparison between Final diagnosis versus POCUS diagnosis

	FINAL DISCHARGE DIAGNOSIS (%)	INITIAL POCUS DIAGNOSIS (%)	CLINICAL ACCURACY (%)
Pneumothorax	8%	7%	87.5%
Pulmonary edema	31%	30%	96.77%
Anterior Pneumonia	32%	30%	93.75%
PLAPS pneumonia	16%	17%	94.11%
COPD/asthma	13%	16%	81.25%
			Overall Accuracy 90.67%

Figure 1:



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