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Etiologic diagnosis of acute shortness of breath in the emergency department

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***Abstract*---**Background-Dyspnea is the term applied to sensation of breathlessness and the patient's reaction to that sensation, In the BLUE (Bedside Lung Ultrasound in Emergency) protocol, lung profiles have been designed for the main etiologies of dyspnea (acute pulmonary edema, COPD, pulmonary embolism, pneumothorax, pneumonia) with an accuracy of >90%. Objectives-•To investigate if BLUE protocol will improve diagnostic accuracy of patients with acute dyspnea •To compare the diagnostic accuracy of BLUE protocol findings alone with final diagnosis in patients with acute dyspnea. Methods-This study was a cross-sectional, hospital-based, follow-up observational study conducted in 130 patients who presented to the Emergency Department of Pushpagiri Institute of Medical Sciences, Tiruvalla, Kerala during January 2020 to August 2020, with complains of dyspnea of acute onset. It was done by incorporating the Bedside Lung Ultrasound in Emergency (BLUE) protocol for diagnosing the etiology of dyspnea. Epiinfo 7 was used for analysis. Results-the study sample included 130 subjects who fulfilled the inclusion criteria. Among the study population,76(58.5%) were males and54(41.5%) were females. The mean age of the study population was 66.6 with a standard deviation of 14.1. The minimum age included in the study was 32 years and the maximum age was 91years. the diagnosis of acute pulmonary edema and pneumothorax using BLUE protocol was made with a sensitivity of 100%, and the diagnosis of COPD/asthma exacerbation was made with 83.3% sensitivity. Pneumonia and pulmonary embolism were diagnosed with

69.2% and 60% sensitivity respectively.Overall, the utilization of BLUE protocol in arriving at a diagnosis has been shown to have an accuracy of > 90% in the sample studied. Conclusion- BLUE protocol has >90% accuracy in the initial diagnosis of patients presenting with acute respiratory distress to the Emergency Department.

***Keywords*---**dyspnea, BLUE protocol, atelectasis, pneumothorax, pulmonary embolism, sensitivity.

Introduction

Dyspnea is the term applied to sensation of breathlessness and the patient's reaction to that sensation. It is an uncomfortable awareness of breathing, which results from various conditions, extending from nonurgent to life-threatening; and has many potential causes, including pulmonary, cardiac, metabolic, infectious, neuromuscular, traumatic, and hematologic.In a consensus statement, the American Thoracic Society defined dyspnea as "a subjective experience of breathing discomfort that consists of qualitatively distinct sensations that vary in intensity"[1].

The diversity of pathophysiologic conditions that produce dyspnea render a simple algorithmic approach difficult.[2]the primary point in the approach to dyspnea is to determine whether it is primarily cardiopulmonary or toxic-metabolic in origin. It is challenging to differentiate as most of the clinical features and history overlap.Very often the Emergency Physician has no time to wait for the blood investigation reportor imaging studies like chest radiograph to initiate treatment. Failure or delay to initiate appropriate treatment in a timely fashion may endanger the life of the patient. Prompt evaluation of acute dyspnea to arrive at an etiologic diagnosis is of outmost importance in making life-saving and focused interventions in initial management of patients in the Emergency Department (ED).

Numerous studies indicate that the physical exam, even with the addition of chest radiography, is often inaccurate in differentiating the causes of dyspnea. [3, 4,5] In the BLUE (Bedside Lung Ultrasound in Emergency) protocol, lung profiles have been designed for the main etiologies of dyspnea (acute pulmonary edema, COPD, pulmonary embolism, pneumothorax, pneumonia) with an accuracy of >90%. [7]. The rationale behind the study was to investigate if BLUE protocol will improve diagnostic accuracy of patients with acutedyspnea.

Materials and Methods

It was a Cross sectional, follow-up observational study conducted at Department of Emergency Medicine, Pushpagiri Institute of Medical Sciences and Research Center, Tiruvalla, Kerala in Patients above the age of 18 years presenting to the Emergency Department with acute onset breathlessness between September 2019 to August 2020. Assuming a Sensitivity of 80% [7]and prevalence as 75% COPD or asthma, along with a relative precision of 20% and an alpha error of 5%, the minimum sample size is 64 using the formula.$n = Z^2 P (1 - P) d^2$ Where n is the

sample size, Z is the statistic corresponding to level of confidence, P is expected prevalence Consecutivesampling was used.

Inclusion criteria

Age ≥ 18 years of both genders, with chief complaint ofbreathing difficulty attriage andAny one or more of thefollowing:

a. HR>100bpm
b. RR>20/min
c. SpO2 < 94% in roomair
d. Increased work ofbreathing
    - Use of accessory muscles ofrespiration
    - Nasalflaring

Exclusion Criteria

Patients not giving consent, Pregnancy, Patients with a metabolic cause for shortness of breath/tachypnea, which is not consistent with the BLUEprotocol

Methodology

After approval from the Ethics committee and Research committee, eligible participants were enrolled into the study after an informed consent. The treating physician began his/her assessment, stabilization and workup of the patient and the investigator was informed. The investigator was blinded to the clinical history (except chief complains of breathlessness) and systemic examination findings of the patient; and performed the BLUE protocol and recorded his/her findings in the USG proforma and formed a diagnosis/ impression of the etiology of breathlessness in the patient. All the patients were followed up during their hospitalization until a final diagnosis was arrived at, which was documented. The final diagnosis (as arrived at by a senior certified consultant) with the help of clinical history, physical examination findings, and reports of the blood investigations and imaging was compared with the impressions made as per BLUE protocol by the investigator.

Ethical Approval and Consent

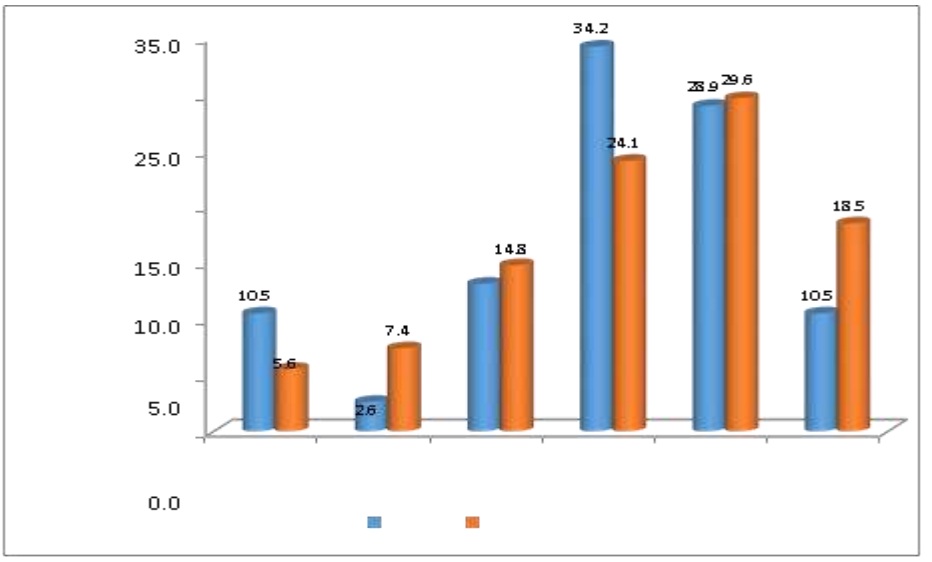
Approval from Institutional Ethics Committee (EC-RegNo. ECR/975/Inst/KL/2017) order no taken. PIMSRC/E1/388A/16/2019 and from the Institutional Research Committee order no. PIMS&RC/IRC/413/'19 dated 23rd May 2019.Written informed consent was taken.

Statistical Analysis

Data was presented as mean ± SD. Comparisons of various parameters among different groups were performed with the Mann– Whitney U-test. The diagnostic performance of each test was calculated as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV). Difference was considered to be significant at P < 0·05. (UsingEpiinfo 7)

Results

Figure 1- Age and Gender wise distribution



As per figure 1 the study sample included 130 subjects who fulfilled the inclusion criteria. Among the study population,76(58.5%) weremalesand54(41.5%) were females. The mean age of the study population was 66.6 with a standard deviation of 14.1. The minimum age included in the study was 32 years and the maximum age was 91years.

Table 1- distribution of the sample according to lung ultrasound profile

Lung ultrasound profile	Count	Percent
A-DVT	3	2.3
A-noV-PLAPS	2	1.5
A-nude	27	20.8
B profile	83	63.8
A/Bprofile	2	1.5
A` profile	7	5.4
B` profile	1	0.8
C profile	5	3.8

As per table 1 the sonographic parameters included 8 lung profiles: A-DVT, A-noV- PLAPS,A-nude,B-profile,B'profile,A/Bprofile,CprofileandA'profile.The most common lung profiles found among the study sample were B-profilein83 (63.8%) of subjects and A-nude profile in 27 (20.8%) of subjects. Distribution of other profiles were viz. A' profile in 7 (5.4%), C profile in 5 (3.8%), A-DVT profile in 3 (2.3%), A-noV-PLAPS profile in 2 (1.5%), A/B profile in 2 (1.5%) and B' profile in 1 (0.8%).

Table 2- Diagnosis Based on BLUE Protocol

Provisional diagnosis	Count	Percent
Acute pulmonary edema	83	63.8
Pulmonary embolism	3	2.3
COPD/Asthma exacerbation	27	20.8
Pneumonia	10	7.7
Pneumothorax	7	5.4

As per table2 the etiology of shortness of breath can be determined as pulmonary edema, pulmonary embolism, COPD/ Asthma, pneumonia or pneumothorax. Of the subjects included in this study, the provisional diagnosis was made as acute pulmonary edema in 63.8%, COPD/ asthma exacerbation in 20.8%, pneumonia in 7.7%, pneumothorax in 5.4% and pulmonary embolism in 2.3%.

Table 3- Comparison of Initial Diagnosis and Final Diagnosis

	Final Diagnosis						
Provisional Diagnosis	Acute pulmonary edema	Pulmonary embolism	COPD/Asthma exacerbation	Pneumonia	Pneumothorax	Pleural effusion	Total
Acute pulmonary edema	75	0	2	0	0	0	83
Pulmonary embolism	0	3	0	0	0	0	3
COPD/Asthma exacerbation	0	2	20	4	0	0	27
Pneumonia	0	0	1	9	0	0	10
Pneumothorax	0	0	1	0	3	1	7
Total	75	5	24	13	3	1	130

As per table 3 the subjects in the study sample were followed up to obtain the final diagnoses which were pulmonary edema in 57.7%, COPD/Asthma exacerbation in 18.5%, pulmonary embolism in 3.8%, pneumothorax in 2.3%, ARDS in 3.8%, hemothorax in 1.5%, LRTI in 1.5% and pleural effusion in 0.8%.

Table 4- Diagnostic Accuracy of BLUE PROTOCOL

	Acute pulmonary edema	Pulmonary embolism	COPD/Asthma exacerbation	Pneumonia	Pneumothorax
Sensitivity	100.0	60.0	83.3	69.2	100.0
Specificity	85.5	100.0	93.4	99.1	96.9
False Negative	0.0	40.0	16.7	30.8	0.0
False positive	14.5	0.0	6.6	0.9	3.1
Positive Predictive value	90.4	100.0	74.1	90.0	42.9
Negative Predictive value	100.0	98.4	96.1	96.7	100.0
Positive Likelihood	6.88	-	12.62	81.00	31.75

ratio					
Negative Likelihood ratio	0.00	0.40	0.18	0.31	0.00
Accuracy	93.8	98.5	91.5	96.2	96.9

As per table 4 the diagnosis of acute pulmonary edema and pneumothorax using BLUE protocol was made with a sensitivity of 100%, and the diagnosis of COPD/asthma exacerbation was made with 83.3% sensitivity. Pneumonia and pulmonary embolism were diagnosed with 69.2% and 60% sensitivity respectively.Overall, the utilization of BLUE protocol in arriving at a diagnosis has been shown to have an accuracy of > 90% in the sample studied.

Discussion

This study was a cross-sectional, hospital-based, follow-up observational study conducted in 130 patients who presented to the Emergency Department of Pushpagiri Institute of Medical Sciences, Tiruvalla, Kerala. This study had 75 patients with a final diagnosis of acute pulmonary edema, and all the 75 cases were identified using BLUE protocol in the ED. It was found that there was 100% sensitivity and 85.5% specificity in diagnosing acute pulmonary edema using BLUE protocol in patients presenting to the ED with complains of acute shortness of breath. The positive predictive value was 90.4% and negative predictive value was 100%. These findings parallel those concluded by Lichtenstein et al[8] and Volpicelli et al [9], which showed > 85% sensitivity and >90% specificity for lung ultrasound in the initial recognition of acute pulmonary edema at the bedside.

In this study population of 130 subjects who presented to the ED with acute shortness of breath, 3 subjects had a final diagnosis of pneumothorax. This study had a 100% sensitivity, and 96.9% specificity, and is in agreement with systematic review and meta-analysis done by Staub L J et al [10] and Alrajab S et al [11], who found that lung ultrasonography is more sensitive than chest radiography in the identification of pneumothorax. This study showed a 60% sensitivity, 100% specificity and an accuracy of 98.5% in the diagnosis of pulmonary embolism using the BLUE protocol. Out of 5 subjects who had a final diagnosis of pulmonary embolism in this study, the presence of deep venous thrombosis could not be demonstrated in 2 subjects. The identification of pulmonary embolism using BLUE protocol requires a combination of A-profile and demonstration of deep venous thrombosis in a patient with shortness of breath and has 81% sensitivity and 99% specificity for pulmonary embolism[3]. Thoracic ultrasonography had high specificity (>89%) in the diagnosis of pulmonary embolism as per Baz A et al[12] and Abootalebi et al[13].

Identification of pneumonia using lung ultrasound showed 69.2% sensitivity and 99.1% specificity. This is in contrary to an observational study conducted by Bourcier JE et al[14] which showed that lung ultrasonography was superior to chest radiography in the diagnosis of pneumonia and had a sensitivity as high as 95%. Nazerian et al[15] also found that lung ultrasonography had a sensitivity of 82.8% for diagnosis of pneumonia in patients with respiratory distress, using CT chest as the gold standard. The present study had a sensitivity of 83.3% and specificity of 93.4% for the diagnosis of COPD/ Bronchial asthma exacerbation

using lung ultrasonography at the bedside. Zhou S et al[16], conducted a single blinded prospective study to assess the he diagnostic accuracy of bedside lung ultrasound examination in chronic obstructive pulmonary disease (COPD) and cardiac pulmonary edema, they concluded that it might be useful in screening for COPD and cardiogenic pulmonary edema.

Conclusion

BLUE protocol has >90% accuracy in the initial diagnosis of patients presenting with acute respiratory distress to the Emergency Department. The findings of BLUE protocol enables an increased diagnostic accuracy of pulmonary edema/ pneumothorax/ pneumonia/ COPD/Bronchial asthma. Bedside lung ultrasonography is cheap, can be performed at ease and quickly detects emergent and life threatening causes of shortness of breath.

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Conflict of Interest- None declared

Author's Contribution

Dr. A has finalized the draft and guarantor, Dr. B and C has prepared the conceptual framework, designing of draft, and data analysis, Dr. D was involved in data collection and analysis, and Dr. E has done manuscript writing and data collection.

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