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Original Research Article

Utility of Bedside Lung Ultrasound in Emergency (Blue) Protocol as a Diagnostic Tool in Patient with Acute Respiratory Distress Presenting in Emergency Department

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Conflict of interest: Nil

Abstract:

Introduction: Majority of patients present in ED having complain of respiratory distress. In India most of the cases of ARDS are due to pneumonia. There are so many radiological and blood investigations are used to diagnose such condition but lung ultrasonography is modern imaging modality which has been studied in the emergency department setting. It is cheaper, safer and does not require expert to operate. This study was aimed to assess the accuracy of BLUE protocol. We compared it prospectively to a composite standard which was chest radiograph, USG chest, and HRCT.

Aims: To determine the utility of bedside lung ultrasound in emergency (BLUE) protocol as a diagnostic tool in patients with acute respiratory distress presenting in the emergency department.

Methodology: Cases of patients presenting with acute respiratory distress aged more than 18 years admitted in tertiary care hospital in India with study period of February 2024 to June 2024 were included in the study. On admission covid 19 positive patients and pregnant females were excluded in the study. Brief history was taken in each case following admission with reference to symptoms like breathlessness, pedal oedema, chest pain or gabharaman and the presence of risk factors like hypertension, diabetes, smoking and alcohol. Radiological investigations like x ray chest, HRCT and other blood investigations were done. All the above data were collected and recorded in a standard proforma.

Result: Total 150 patients of acute respiratory distress were included in study as per inclusion and exclusion criteria. Out of that 94 patients were male and 56 were females. Out of 150 patients most common cause of acute respiratory distress is pulmonary oedema (30%), COPD or asthma (14.67%), pulmonary embolism (4%), pneumothorax (10%) and pneumonia (40%). For pulmonary edema, the B profile had 97% sensitivity and 94% specificity. For COPD or asthma, the normal profile had 90% sensitivity and 97% specificity. For pulmonary embolism A profile plus venous thrombosis showed 83.3% sensitivity and 97% specificity. For pneumothorax, absent anterior lung sliding, anterior A lines, and a positive search for lung point yielding 86% sensitivity and 98% specificity. For pneumonia, sensitivity and specificity were respectively,11% and 98% for B' profile,14% and 98% for the A/B profile, 22% and 98% for C profile, 44% and 97% for the A profile plus PLAPS. These four profiles indicated pneumonia with 90% sensitivity and 93% specificity.

Conclusion: Lung ultrasound can help the ED physician make a rapid diagnosis in patients with acute respiratory distress. And it is feasible, affordable and allows fast, accurate, bedside examinations of most acute respiratory disorders. Lung ultrasound immediately provides diagnosis of acute respiratory failure in the majority of cases.

Keywords: Bedside Lung Ultrasonography In Emergency Department Protocol, Acute Respiratory Distress, Emergency Medicine Department Of Tertiary Care Hospital In India, Sensitivity, Specificity.

Introduction

Lung ultrasound is part of critical ultrasound defined as a whole -body approach using simple machines, one universal probe, and new applications[1]. The BLUE Protocol, performed on dyspnea patients who will be admitted to intensive care unit (ICU), is a fast protocol requiring less than 3 minutes using suitable machines and standardized points of analysis. Based on

pathophysiology it provides step-by-step diagnosis of the main causes of acute respiratory failure ,covering six diseases seen in 97% of patients in the emergency room, offering an overall 90.5% accuracy [2].In the BLUE protocol three standardized points are the upper BLUE point, lower BLUE point and PLAPS points. Similar to the six leads of ECG, the six BLUE Points (three on each hemithorax) help in reproducible analysis of acute respiratory distress. The main advantage is that it is portable and does not expose the patient to harmful X rays and do not require transportation of unstable patient. Acute respiratory distress is one of the most distressing situations for the patient. Emergency cases do not always present in conditions that are ideal for immediate diagnosis, which sometimes compromise the outcome of the patient. Lung ultrasonography is becoming a standard tool in critical care [3].

Aims:

To determine the utility of Bedside lung ultrasound in emergency (BLUE) Protocol as a diagnostic tool in patient with acute respiratory distress presenting in the emergency department.

Primary Objectives:

1. To determine the accuracy of the BLUE protocol in predicting the correct diagnosis in patients presenting with acute respiratory distress in the emergency department.
2. To determine the role of BLUE protocol as a bedside tool for early and prompt management in various respiratory distress conditions.
3. To determine the sensitivity and specificity of BLUE protocol with gold standard investigation.

Secondary Objectives: To evaluate various aetiology of acute respiratory distress including pulmonary edema, pneumonia, COPD, asthma, pneumothorax and pulmonary embolism.

Materials and Methods

This is a prospective and observational study done in 150 cases of patients presenting with acute respiratory distress admitted to SVPIMSR.

Patients aged more than 18 years with study period of February 2024 to June 2024 were included in the study on admission covid 19 positive patients and pregnant females were excluded in the study.

Brief history was taken in each case following admission with reference to symptoms like breathlessness, pedal edema, chest pain or gabharaman and the presence of risk factors like hypertension, diabetes, smoking and alcohol.

Radiological investigations like x ray chest, HRCT, and other blood investigations were done. All the above data were collected and recorded in a standard proforma.

	Compared With Gold Standards (X ray Chest/HRCT Thorax/USG Chest)	
	Positive	Negative
Positive findings in lung scan	True positive (TP)	False positive (FN)
Negative findings in lung scan	False negative (FN)	True negative (TN)

Sensitivity=TP/(TP+FN), Specificity=TN/(TN+FP), Positive predictive value (PPV)=TP/(TP+FP) Negative predictive value (NPV)=TN/(TN+FN) Sensitivity, specificity, PPV, NPV are calculated in this study by positive findings in lung scan which is done by ER physician compared with gold standard radiological investigation either X-ray/HRCT/USG chest.

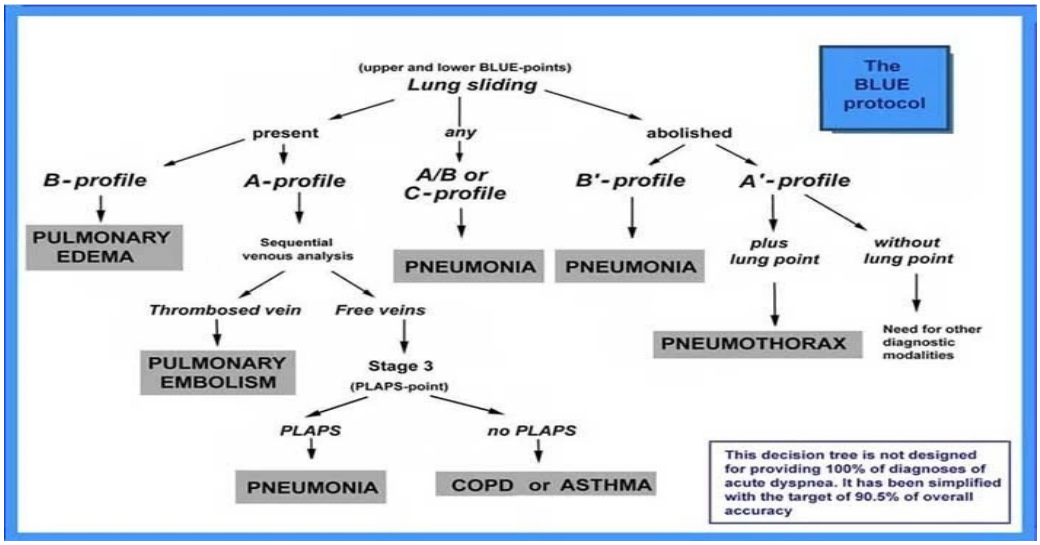

Figure 1: The BLUE-protocol decision tree

This tree indicates a way proposed for immediate diagnosis of the main cause of acute respiratory failure, using a lung and venous ultrasound approach.

This image is taken from Daniel Lichtenstein study of lung ultrasound in critically ill Kind permission of Springer Science.

Inclusion Criteria:

1. Age>=18 years
2. Patients presenting with respiratory complaints or signs and symptoms of respiratory distress.
3. Patient /relatives willing to be included in the study.

Exclusion Criteria:

1. Pregnant females
2. Active covid 19 positive patients.

Results:

Table 1: Gender distribution in this study

Total	Male	Female
150	94(62.67%)	54 (37.33%)

Table 2: Addiction among patients of acute respiratory failure

Addiction	Total no of patients
Smoker	41(27.3%)
Tobacco chewer	25(16.67%)
Alcoholic	15(10%)

Table 3: Most common causes of acute respiratory distress in this study

Disease	Ultrasound sign	Total no of case
Cardiogenic pulmonary edema	Diffuse bilateral anterior B+ lines associated with lung sliding (B profile)	46(30%)
COPD Or Asthma	Predominant anterior A lines without PLAPS and with lung sliding (normal profile), or with absent lung sliding without lung point	22(14.67%)
Pulmonary embolism	Predominant anterior bilateral A lines plus venous thrombosis	6(4%)
Pneumothorax	Absent anterior lung sliding, absent anterior B lines and present lung point	15(10%)
Pneumonia	B' profile, A-B profile, C profile, A profile + PLAPS ,4 profiles (B', A-B, C, A+PLAPS)	61(40%)

Table 4: Accuracy of lung ultrasound in predicting Cardiogenic pulmonary edema

Lung scan by ED physician	Compared with gold standard		
	Positive	Negative	Total
Positive	45	6	51
Negative	1	98	99
	46	104	150

Sensitivity =45/45+1=97.82%, PPV = 45/45+6=88.23%, Specificity =98/98+6=94.23%, NPV = 98/98+1 =88.23% .

Table 5: Accuracy of lung ultrasound in predicting COPD and Asthma

Lung Scan by ED Physician	Compared with gold standard		
	Positive	Negative	Total
Positive	20	03	23
Negative	02	125	127
	22	128	150

Sensitivity =20/20+2=90.90%, PPV=20/20+3=86.96%, Specificity=125/125+3=97.65%, NPV=125/125+2=98. 42%.

Table 6: Accuracy of lung ultrasound in predicting Pulmonary Embolism

Lung scan by ED physician	Compared with gold standard		
	Positive	Negative	Total
Positive	05	04	09
Negative	01	140	141
	06	144	150

Sensitivity =5/5+1=83.3%, PPV = 5/5+ 4 =55.5%, Specificity=140/140+4=97.2%, NPV=140/140+1=99.29%.

Table 7: Accuracy of lung ultrasound in predicting Pneumothorax

Lung Scan by ED Physician	Compared With Gold Standard		
	Positive	**Negative**	**Total**
Positive	13	02	15
Negative	02	133	135
	15	135	150

Sensitivity =13/13+2=86.6%, PPV = 13/13+02=86.6%, Specificity=133/133+2=98.51, NPV=133/133+2=98.51%.

Table 8: Accuracy of lung ultrasound in predicting Diffuse bilateral anterior B + Lines associated with abolished lung sliding

Lung scan by ED physician	Compared With Gold Standard		
	Positive	**Negative**	**Total**
Positive	7	1	8
Negative	54	88	142
	61	89	150

Sensitivity =7/7+54=11.4%, PPV = 7/7+1= 87.5%, Specificity=88/88+1=98.87%, NPV =88/88+54=61.97%.

Table 9: Accuracy of lung ultrasound in predicting Predominant anterior B + lines on one side, predominant anterior A lines on other (A/B Profile)

Lung scan by ED physician	Compared with gold standard		
	Positive	**Negative**	**Total**
Positive	9	1	10
Negative	52	88	140
	61	89	150

Sensitivity =9/9+52=14.75% PPV = 9/9+1 =90%, Specificity=88/88+1=98.87% NPV =88+88+52=62.86%.

Table 10: Accuracy of lung ultrasound in predicting Anterior alveolar consolidation(C Profile)

Lung scan by ED physician	Compared with gold standard		
	Positive	**Negative**	**Total**
Positive	14	01	15
Negative	47	88	135
	61	89	150

Sensitivity =14/14+47=22.95% PPV = 14/14+1=93.33%, Specificity=88/88+1=98.88% NPV = 88/88+47=65.18%.

Table 11: Accuracy of lung ultrasound in predicting A profile plus PLAPS

Lung scan by ED physician	Compared with gold standard		
	Positive	**Negative**	**Total**
Positive	27	2	29
Negative	34	87	121
	61	89	150

Sensitivity =27/27+34=44.26% PPV =27/27+2 =93.10%, Specificity=87/87+2=97.75% NPV =87/87+34=71.90%.

Table 12: Accuracy of lung ultrasound in predicting 4 Profile (A Profile Plus PLAPS,B',A/B Or C Profile)

Lung scan by ER physician	Compared With Gold Standard		
	Positive	**Negative**	**Total**
Positive	55	6	61
Negative	6	83	89
	61	89	150

Sensitivity =55/55+6=90.16% PPV = 55/55+6 =90.16%, Specificity=83/83+6=93.25% NPV = 83/83+6=93.25%.

Table 13: Accuracy of Ultrasound Profile

Disease	Sensitivity	Specificity	PPV	NPV
Cardiogenic Pulmonary Edema	97.82% (45/46)	94.23% (98/104)	88.23%	88.23%
Copd Or Asthma	90.90% (20/22)	97.65% (125/128)	86.96%	98.42%
Pulmonary Embolism	83.3% (5/6)	97.22% (140/144)	55.5%	99.29%
Pneumothorax	86.67% (13/2)	98.51% (133/135)	86.6%	98.51%
Pneumonia				
B' Profile	11.47% (7/61)	98.87% (88/89)	87.5%	61.97%

A/B Profile	14.75% (9/61)	98.87% (88/89)	90%	62.86%
C Profile	22.9% (14/61)	100% (89/89)	93.33%	65.18%
A Profile +PLAPS	44.2% (27/61)	97.75% (87/89)	93.10%	71.90%
A Profile Plus Plaps, B', A/B Or C Profile	90% (55/61)	93.25% (83/89)	90.16%	93.25%

For pulmonary oedema, the B profile had 97% sensitivity and 94% specificity. For COPD or asthma, the normal profile had 90% sensitivity and 97% specificity.

For pulmonary embolism A profile plus, venous thrombosis showed 83.3% sensitivity and 97% specificity. For pneumothorax, absent anterior lung sliding, anterior A lines, and a positive search for lung point yielding 86% sensitivity and 98% specificity. For pneumonia, sensitivity and specificity were respectively, 11% and 98% for B' profile, 14% and 98% for the A/B profile, 22% and 98% for C profile,44% and 97% for the A profile plus PLAPS.

These four profiles indicated pneumonia with 90% sensitivity and 93% specificity.

Table 14: Disposition of patient

Disposition	Number of Patients	Percentage
DAMA	20	13.33%
Death	54	36%
Discharge	76	50.66%
Total	150	100%

Among 150 patients of acute respiratory failure 20(13.33%) patients took discharge against medical advice 54 patients were dead, and 76 (50.66%) were discharged from hospital.

Discussion

Table 15: Gender distribution comparable with other study

	Male	Female
In This Study	62.67%	37.33%
Seyedhosseini J et al Study [4]	58%	42%
Shahid Iqbal et al Study [5]	67.10%	32.90%
Mc Nicholas BA et al Study [6]	62%	38%
Burak Bekgoz et al study [7]	52.2%	47.8%
Vargas munoz SM et al Study [8]	53.5%	46.4%

In the present study among 150 patients with acute respiratory failure presenting in the emergency department, (62.67%) patients were male compared to females(37.33%) and male to female ratio is 1.74:1. Which is comparable with other study as in Seyedhosseini J et al study observed that 58% were males and 42% were females[4]. According to Shahid Iqbal et al study 67.10% were males and 32.90% were females[5]. In Mc Nicholas BA et al study 62% were males and 38% were females[6]. In A study by Burak Bekgoz et al 52.2% were males and 47.8% were females[7]. In Varagazmanoz SM et al study 53.5% were males and 46.4% were females[8].

Table 16: Addiction among patients of acute respiratory failure

Addiction	Total no of patients	Calfee CS et al study [9]
Smoker	41(27.3%)	36%
Tobacco chewer	25(16.67%)	1.4%
Alcoholic	15(10%)	11%

In this study of 150 patients of acute respiratory failure patients n=41(27.3%) were smoker, n=25 (16.67%) were tobacco chewer and n=15 were alcoholic (10%) which is comparable with other study as in Calfee CS et al study 36% were smoker 1.4% were tobacco chewer and 11% were alcoholic [9]. And most common addiction found to be in our study as well as other study was smoking.

Table 17: Comparison of most common cause of acute respiratory distress with other study

Study	Pneumonia	Pulmonary Edema	COPD/ Asthma	Pneumothorax	Pulmonary Embolism
In this study	40%	30%	14.67%	10%	4%
Seyedhosseini J et al Study [4]	52%	24%	8%	8%	10%
Ray P et al study [10]	35%	43%	32%	-	18%

Among 150 patients of acute respiratory failure in this study most common cause of acute respiratory failure was pneumonia which was n= 61(40%), followed by cardiogenic pulmonary edema

46(30%), followed by COPD and asthma n=22 (14.67%), pneumothorax n=15(10%), and pulmonary embolism n=6 (4%). Comparable with other studies as in Seyedhosseini J et al Study total no of patients presented with pneumonia were 52%, total no of patients of pulmonary edema were 24%, COPD and asthma 8%, pneumothorax 8% and pulmonary embolism were 10%[4].

And in Ray P et al study 35% patients were suffering from pneumonia, 43% were having pulmonary edema, 32% were having COPD/Asthma, 10% patients having pneumothorax and 18% patients having pulmonary embolism[10].

Table 18: Accuracy of the BLUE protocol

		In This Study	In Daniel A. Lichtenstein et al Study[3]	In Burak Bekgoz et al Study [7]
Pulmonary Edema	Sensitivity	97.82%	97%	87.6%
	Specificity	94.23%	95%	96.2%
Asthma/COPD	Sensitivity	90.90%	89%	98.2%
	Specificity	97.65%	97%	67.3%
Pulmonary Embolism	Sensitivity	83.3%	81%	46.2%
	Specificity	97.22%	99%	100%
Pneumothorax/ Haemothorax	Sensitivity	86.67%	88%	71.4%
	Specificity	98.51%	100%	100%
Pneumonia (B' Profile)	Sensitivity	11.47%	11%	85.7%
	Specificity	98.87%	100%	99%
Pneumonia (A/B Profile)	Sensitivity	14.75%	14.5%	-
	Specificity	98.87%	100%	-
Pneumonia (C Profile)	Sensitivity	22.9%	21.5%	-
	Specificity	98.87%	99%	-
Pneumonia (A + Plaps)	Sensitivity	44.2%	42%	-
	Specificity	97.75%	96%	-
Pneumonia (4 Profile)	Sensitivity	90%	89%	-
	Specificity	93.25%	94%	-

Accuracy of ultrasound profile is comparable with other study as in Daniel A. Lichtenstein et al study sensitivity of pulmonary edema is 97% and specificity is 95%. Sensitivity of Asthma/COPD is 89% and specificity is 97%. Sensitivity of pulmonary embolism is 81% and specificity is 99% Sensitivity of pneumothorax is 88% specificity 100% [3]. And in Burak Bekgoz et al study sensitivity of pulmonary edema is 87.6% and specificity is 96.2%. Sensitivity of asthma/COPD is 98.2%, and specificity is 67.3%. Sensitivity of PE is 46.2% and specificity is 100%. Sensitivity of pneumothorax/haemothorax is 71.4% and specificity is 100%. Sensitivity and specificity of pneumonia is 85.7% and 99% [7].

Conclusion:

Lung ultrasound is a holistic discipline which is feasible, affordable and allows fast, accurate, bedside examinations of most acute respiratory disorders. The BLUE protocol directly scans the lung to assess the cause of a respiratory failure and it can be easily used by emergency physicians without any complex adaptation. The versatility of lung ultrasound heralds a kind of visual medicine, where minimal training is required for acquiring and interpretation of images and hence it has gained popularity in intensive care as well as many other disciplines. Lung ultrasound immediately provides diagnosis of acute respiratory failure in the majority of cases and it can therefore be added to the armamentarium of critical care. In a low resource country like India, where access to advanced facilities like that of CT scan machine is difficult, ultrasound provides the additional value of saving time and early diagnosis and management for severely dyspnoeic patients.

Limitation of Study: Single centre study, small sized samples, very short period of time

Ethical statement: Ethical permission was received from the institutional review board Smt. NHLMMC, Ahmedabad, Gujarat.

List of abbreviation: BLUE-Bedside lung ultrasonography in Emergency department, COPD-Chronic obstructive pulmonary disease, PE-Pulmonary embolism, ED-Emergency department, ARDS - Acute respiratory distress, USG-Ultrasonography, HRCT-High resolution computed tomography, PLAPS-Posterolateral alveolar and/or pleural syndrome, ECG-Echocardiogram, ICU-Intensive care unit, DAMA-Discharge against medical advice

Author's contributions: Dr Urjita Modi, Dr Pratiksha Deshmukh, Dr Rajvi Dave, Dr Gaurang

Patel, Dr Harsh Dangi have contributed to the conceptualization, data curation, formal analysis, investigation, methodology, resources and writing (original draft).

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