

Original Research Article

Evaluation of patient presenting with acute respiratory distress at emergency department in a tertiary care hospital with special reference to bed side thoracic ultrasound

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Abstract

Introduction: Heterogeneous group of patients present with shortness of breath at emergency department. Initial and rapid diagnosis may be lifesaving. Bilateral diffuse anterior B-lines (3 or more) along with lung sliding (B-Profile) have been demonstrated to predict acute hemodynamic pulmonary edema (AHPE) in the BLUE (Bedside Lung Ultrasound in Emergency) protocol. **Objectives:** The objectives of this study are to find out causes of acute onset of dyspnea with special reference to bedside lung ultrasound. **Methodology:** In this study total number of the cases (N=438) were divided in acute hemodynamic pulmonary edema (AHPE Group, n=194) [i.e. B-Profile or (B/L) interstitial syndrome (3 & 3+ B-Line in all six BLUE points with lung sliding bilaterally)] and in the other – Group (n=244)[A/C/A-B profile]. **Results:** This AHPE-Group has significant low ejection fraction (44.28 ± 10.92 with P value = 0.0001); significant low saturation at presentation (82.82 ± 13.91 with P value = 0.0001) and significant high blood lactate level (2.41 ± 1.91 with P value = 0.0049). Total numbers of consolidation (pneumonia) found by bedside ultrasound in “Other” group was significantly higher than AHPE group (P value = 0.02426). **Conclusion:** Bedside lung ultrasound is a very useful tool to evaluate acute onset of dyspnea and to initiate prompt management.

Keywords: Acute respiratory distress, acute hemodynamic pulmonary edema (AHPE), dyspnea, emergency department, thoracic ultrasound, pulse oximetry, echocardiography

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Introduction

Dyspnea / Shortness of breath (SOB) / Breathlessness, which is defined as a subjective inability to breathe comfortably, is a common primary complaint among patients in the emergency department (ED) [1]. Respiratory sensations are the consequence of interactions between the efferent, motor output from the brain to the ventilatory muscles & afferent, sensory input from receptors throughout the body & integrative processing of this information that be occurring in the brain.

Mismatch between feed forward message to ventilatory muscles & feedback from receptors that monitor response of ventilatory pump increases the intensity of dyspnea. There are many scales to measure the depth of dyspnea [2, 3].

Modified medical research center (mMRC scale) [4, 5]

- Grade 0: dyspnea with strenuous exercise
- Grade 1: dyspnea when hurrying on level ground or walking up a slight hill
- Grade 2: walks slowly than people of same age because of dyspnea or have to stop for breath when walking at own pace
- Grade 3: stop for breath after walking about 100 yards or after a few minutes on level ground
- Grade 4: too breathless to leave the house, breathless on dressing or undressing

To find out the causes of dyspnea, they are to be divided in two following groups.

- Acute onset or sudden onset of shortness of breath

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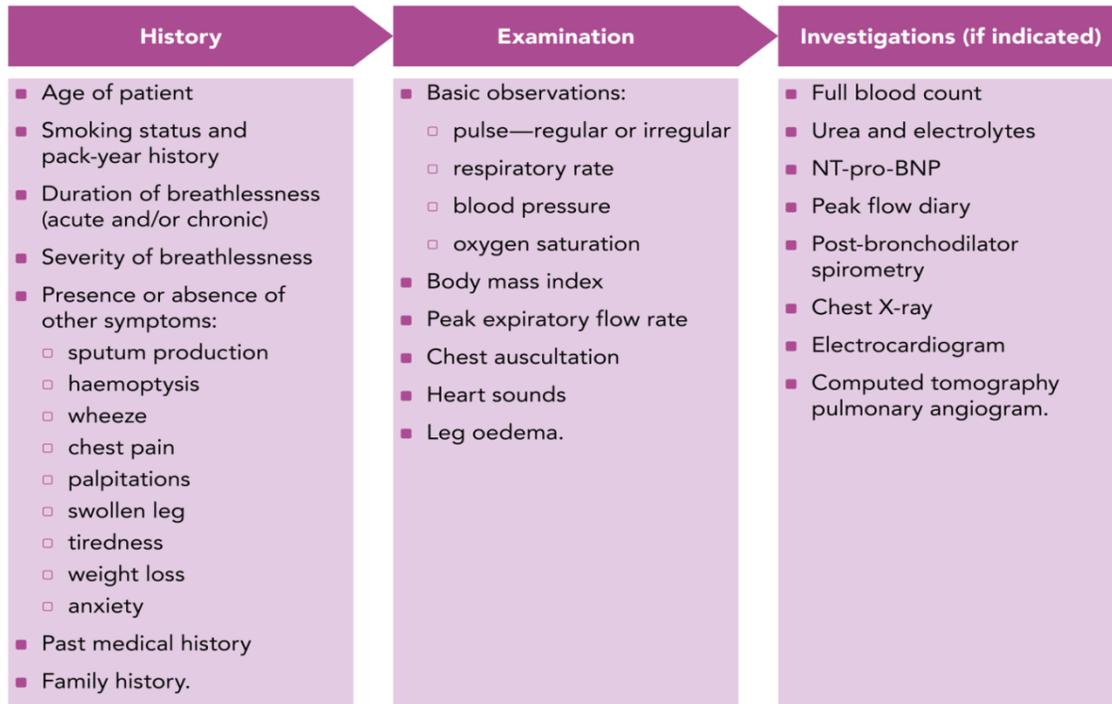
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➤ Chronic onset of shortness of breath
As this study is based on emergency purpose, so here we were dealing mainly with acute/sudden onset of shortness of breath. Causes are (1) cardiac causes, respiratory causes, metabolic causes and the others. Cardiac causes include pneumothorax, myocardial infarction, arrhythmia and pulmonary embolism. Respiratory causes include

acute exacerbation of COPD, pneumonia, ILD, pleural effusion, flail chest, haemothorax and foreign body obstruction. Metabolic causes include DKA, acidosis and sepsis. Other causes include hypoglycemia, CVA, anemia, psychological/functional and obesity. To evaluate a patient with shortness of breath presenting at ED history, clinical examination and investigations were done.



Bilateral diffuse anterior B-lines (3 or more) along with lung sliding (B-Profile) have been demonstrated to predict acute hemodynamic pulmonary edema (AHPE) in the BLUE (Bedside Lung Ultrasound in Emergency) protocol. Though heart failure is a clinical diagnosis, rapid confirmation by reliable bedside tests may be lifesaving. There is dearth of data about the utility of B-line acute in acute onset dyspnea in emergency department, not only in Indian but also in Asian population [6, 7]. Recent studies have also demonstrated its high sensitivity and specificity in the diagnosis of heart failure, pneumonia, pneumothorax, pulmonary embolism, and pleural effusion. Published performances of lung ultrasound in critically ill patients compared with CT scanning [8].

Ultrasound	Sensitivity %	Specificity %
Pleural Effusion	94	97
Alveolar Consolidation	90	98
Interstitial Syndrome	100	100
Complete Pneumothorax	100	96
Occult Pneumothorax	79	100

Aims & Objectives

- To search for the etiology of the dyspnea (whether it is a lung cause or the cardiac cause or others)
- To initiate the primary treatment as soon as possible after knowing the cause of the dyspnea, thus increasing survival rate
- To improve the quality of health care

Materials & Methods

All patients with shortness of breath presenting at Emergency Dept, NH Narayana Multispeciality Hospital, Barasat, West Bengal between Jan 2019 to Jan 2020 were studied for above cross sectional study.

Sample size was 438 subjects. About 438 subjects of sob patients were selected consecutively after applying inclusion and exclusion criteria and with informed consent.

Inclusion Criteria

1. Patients arriving in emergency aged 18 years or above are included in this study.
2. Patient coming to emergency with a chief complaint of respiratory distress, shortness of breath or dyspnea on Exertion.

Exclusion Criteria

1. Patient less than 18 years of age (pediatric age group) were not included in this study.
2. Pregnant patients were excluded.
3. Trauma cases

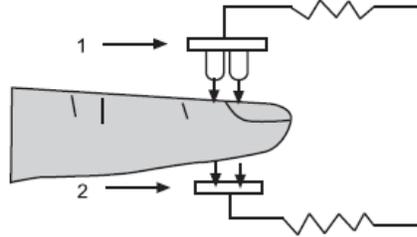
Parameters Studied

Arterial blood gas analysis [ABG] for pH, PaO₂, PaCO₂, HCO₃, Lactate; chest skiagram PA, AP-portable (sitting), AP portable-supine view; oxygen saturation (by pulse oxymetry) [SpO₂]; bed side ultrasonography of thorax for A-Lime, B-Line, A-Profile, A-B-Profile, C-profile; ECG and echocardiography.

Pulse oximetry

All patients were subjected to do the measurement of oxygen saturation at room air to know the status of hypoxemia at the time of presentation of pulse oximetry. Principle of this method two diode emitting red (660 nm wave length) and infra-red (940nm wave length) are focused on clamped finger. Oxygenated Hb absorbed red and deoxygenated Hb absorbed infra red light preferentially. Then

measured signals are obtained by photosensitive element and processed to useful information [9].

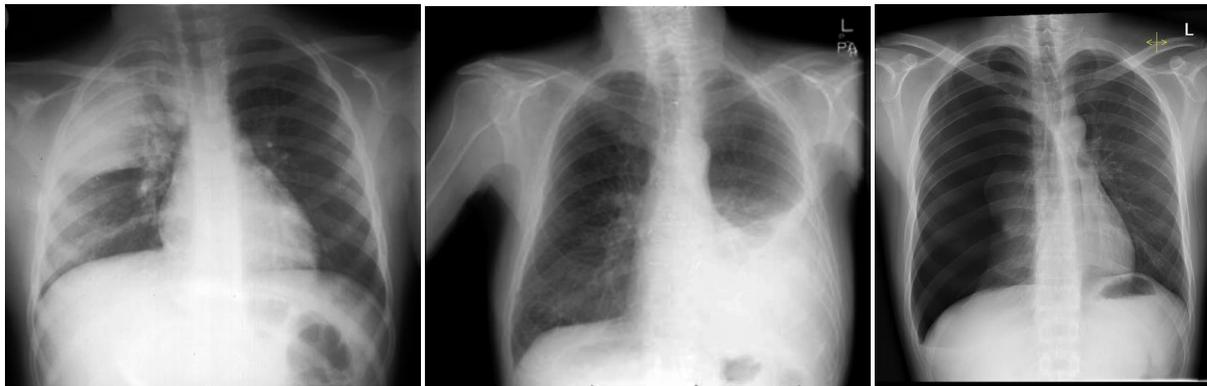


1. Red and Infrared-ray Emission Tube
2. Red and Infrared-ray Receipt Tube

Chest X-ray

Radio-Opacity (whiteness) means – increased density: alveolar pattern & consolidation – pneumonia; interstitial pattern – DPLD; vascular pattern; miliary mottling / shadows; nodules/mass lesion; collapse / fibrosis, effusion and calcification

Radio-translucency (blackness)- decreased density: emphysema, bulla /cyst / cavity, pneumothorax and gas filled bowel loop-diaphragmatic hernia [10]



Pneumonia

Effusion

Pneumothorax

In cases of acute breathlessness presenting at ER dept, main concentration were given on pneumonia, pneumothorax, pleural effusion. Two substances of same density in direct contact cannot be differentiated from each other on X-ray. Loss of normal radiographic silhouette (contour) is called silhouette sign. Silhouette sign helps to localise disease as each lobe produces characteristic silhouette sign [11].

Involvement of lobe/ segment

Silhouette Sign	Adjacent lobe/segment
Ascending Aorta	Right Upper Lobe (anterior segment)
Right Heart border	Right Middle Lobe
Right hemi Diaphragm	Right Lower Lobe (basal segment)
Rt heart border + Rt hemi Diaphragm	Right Middle Lobe + Right Lower Lobe
Aortic knob	Left Upper Lobe (posterior segment)
Left Heart border	Lingula (inferior segment)
Descending Aorta	Left Lower Lobe (superior segment)
Left hemi Diaphragm	Left Lower Lobe (basal segment)

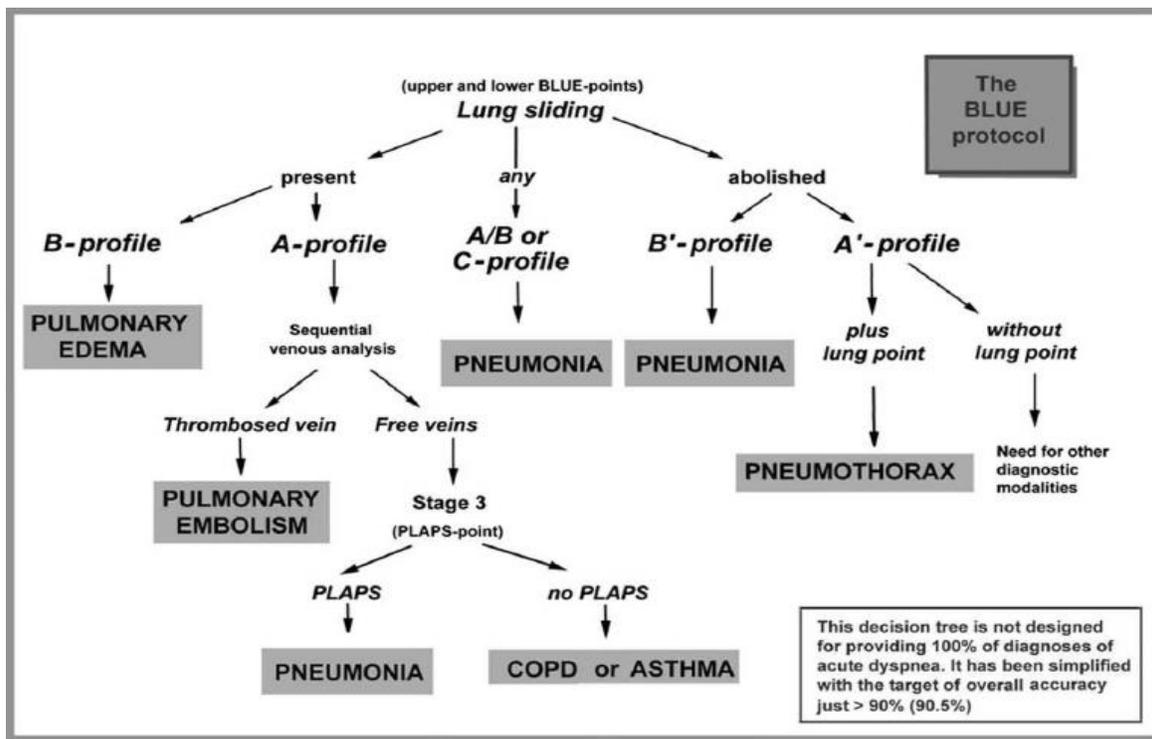
Lung Ultrasound / Thoracic USG

With recent advancement, typical artifacts and some real images produced by interaction of ultrasound beam with air-fluid interface help to make early diagnosis. Many bed-side real time protocols [the bedside lung ultrasound in emergency (BLUE)-protocol for the immediate diagnosis of acute respiratory failure and the fluid administration limited by lung sonography (FALLS)-protocol] are in clinical use now. The **A-line** which is “reverberation” artifact, is a repetition of the pleural line (white horizontal line). A-Line with pleural sliding signify normal lung. The **B-Lines** are vertical white thick lines which start from pleura, traverse throughout, abolish A-Line. It is also known as “lung comet” or “lung rocket”. Fluid in alveolar space produces multiple B-Lines in ultrasound (Interstitial Syndrome) [8].



At the anterior chest wall, normal lung sliding with predominant A-lines define the **A-profile**. The A-profile indicates a normal lung surface. Lung sliding with lung rockets define the **B-profile** and usually indicate Acute hemodynamic pulmonary edema (AHPE). Hemodynamic pulmonary edema creates a transudative, pressurized pulmonary edema, therefore associating lung sliding with lung rockets (multiple B-lines → 3 or more). Anterior lung rockets associated with abolished lung sliding define the **B'-profile**. It is seen in inflammatory interstitial syndrome (pneumonia). Unilateral rockets define the **A/B-profile**. This asymmetry of interstitial signs is also linked to pneumonia.

Anterior lung consolidation, regardless of number and size defines the **C-profile**. In the BLUE-protocol, the C-profile is associated with pneumonia. Shredded sign, Irregular pleural line, Alveolar Opacity (Tissue like sign), Both Dynamic and static air-bronchogram suggest consolidation (Pneumonia). Anterior A-lines associated with abolished lung sliding define the **A'-profile**. The A'-profile + the lung point is defines pneumothorax. A-profile without DVT but with posterolateral alveolar and/or pleural syndrome (A-no-V-PLAPS profile) indicate pneumonia, A-profile plus DVT indicates pulmonary embolism [12].



Echocardiography (2D-TTE)

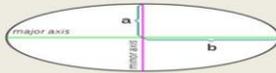
An echocardiography (ECHO) is a test that uses high frequency sound waves (ultrasound) to make pictures of your heart. The test is also called echocardiography or diagnostic cardiac ultrasound [13].

Types of echocardiography are transthoracic echocardiography (TTE), transesophageal echocardiography (TEE), stress echocardiography and intravascular ultrasound. An echocardiogram shows an enlarged heart; weakened heart muscles; left ventricular function (LVEF); problems with heart valves; congenital heart defects and blood clots or tumors.

LVEF is calculated by Teichholz's Formula/Cubed Formula [14]:

TEICHOLZ /CUBED FORMULA

- LV Volume calculation is based on assumption that the LV is a prolate ellipse

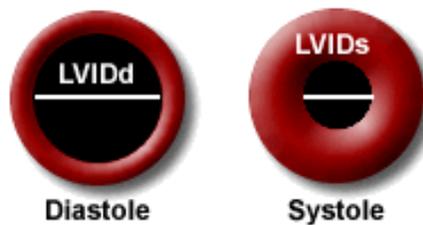
$$\begin{aligned} \text{LV VOLUME} &= 4/3 \times \pi \times D1/2 \times D1/2 \times 2D1/2 \\ &= \pi/3 \times D \text{ cube} = 1.047 \times D \text{ cube} = D \text{ cube} \end{aligned}$$


This structure has two minor axis D1 & D2 and a major axis L

$$V = 4/3 \pi \times D1/2 \times D2/2 \times L/2$$

- Basic assumptions
 - LV dilates along the minor axis
 - LV internal diameter is equal to one of the minor axis of the ellipse D1
 - Both minor axis of ellipse D1,D2 are equal

LVEF by Teicholz



$$\begin{aligned} V_d &= [7/(2.4 + LVID_d)] \times LVID_d^3 \\ V_s &= [7/(2.4 + LVID_s)] \times LVID_s^3 \\ \text{LVEF} &= (V_d - V_s) / V_d \end{aligned}$$

Data collected from this study were plotted on Excel sheets. They were sorted then. Statistical methods (mean, median, mode, Chi-square test, Student t Test) were done with help of Excel, SPSS software.

- Patients of paediatric age group were excluded from the study
- Trauma patients were not taken into inclusion of the study
- Unavailability of NT-Pro BNP kit in emergency department

Limitation of the Study

- It was a single centered study comprising of only emergency department patients of Narayana Multi-specialty Hospital, Barasat, West Bengal
- Pregnant patients with dyspnoea were not included in the study

Results

In this study total number of cases, presented with respiratory distress in emergency at NH Narayana Multispecialty Hospital, Barasat was 438. Among them 273 cases were male and 165 cases female [Table 1]

Table 1: Gender distribution among cases [N=438]

Male		Female		Total	
n	%*	n	%*	n	%*
273	62.33	165	37.67	438	100

* All% to total 438

Mean age for total population is 64.92±12.68 yrs with median 68 and mode 70. Mean age of male was 67.73±9.84 yrs with median 69 and mode 70. Mean age for female was 60.27±15.27 with median 64 and mode 70. Majority of the admitted patients were having hypertension 64.15% followed by diabetes 54.34% and COPD/OAD 39.96% [Table 2/ Fig. 1].

Table 2: Co-morbidity wise distribution [N=438]

Co-morbidity	Male		Female		Total	
	n	%*	n	%*	n	%*
Diabetes	142	32.42	96	21.92	238	54.34
Hypertension	177	40.41	104	23.74	281	64.15
COPD/OAD	133	30.37	42	9.59	175	39.96
Ischemic Heart Disease	83	18.95	46	10.50	129	29.45
CKD	78	17.81	32	7.30	110	25.11
CVA	17	3.88	6	1.37	23	5.25

* All % to total 438

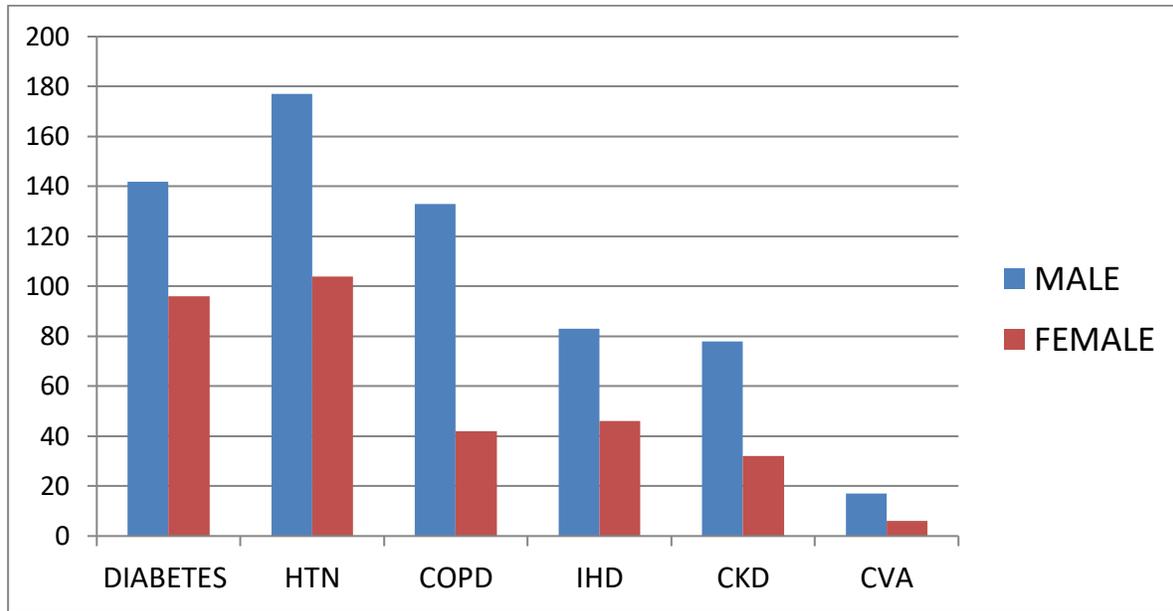


Fig 1: Distribution of Co-morbidities (with male-female division)

All patients presented with breathlessness were also having following symptoms like cough 77.17%, chest pain 14.84%, fever 28.08% and syncope 1.14% [Table 3].

Table 3: Distribution of symptoms [N-438]

Symptoms	Male		Female		Total	
	n	%*	n	%*	n	%*
Cough	205	46.80	133	30.37	338	77.17
Chest pain	40	9.14	25	5.70	65	14.84
Fever	75	17.12	48	10.96	123	28.08
Syncope	3	0.68	2	0.46	5	1.14

* All % to total 438

Mean SpO2 of all patients presented with shortness of breath at emergency is 87.49 ± 12.14 %.

Table 4: Distribution of SpO2 [N-438]

Characteristics (N)	Mean	SD	Median	Mode
Male (273)	86.27	±12.03	90	96
Female (165)	89.51	±10.23	90	88
Total (438)	87.49	±12.14	90	90

Total number of the cases included in acute hemodynamic pulmonary edema (AHPE – Group) [i.e. – B-Profile or (B/L) Interstitial syndrome (presence of 3 & 3+ B-Line in all six BLUE points with lung sliding bilaterally)] was 194. Rest cases (n=244) were in the other – Group [A/C/A-B profile] [Table 5/Fig. 2].

Table 5: Distribution of [AHPE or B-Profile] – Group & [Other] – Group

Group	Male		Female		Total	
	n	%*	n	%*	n	%*
AHPE or B-Profile	109	24.88	85	19.40	194	44.29
Other	164	37.44	80	18.26	244	55.70

* All % to total 438

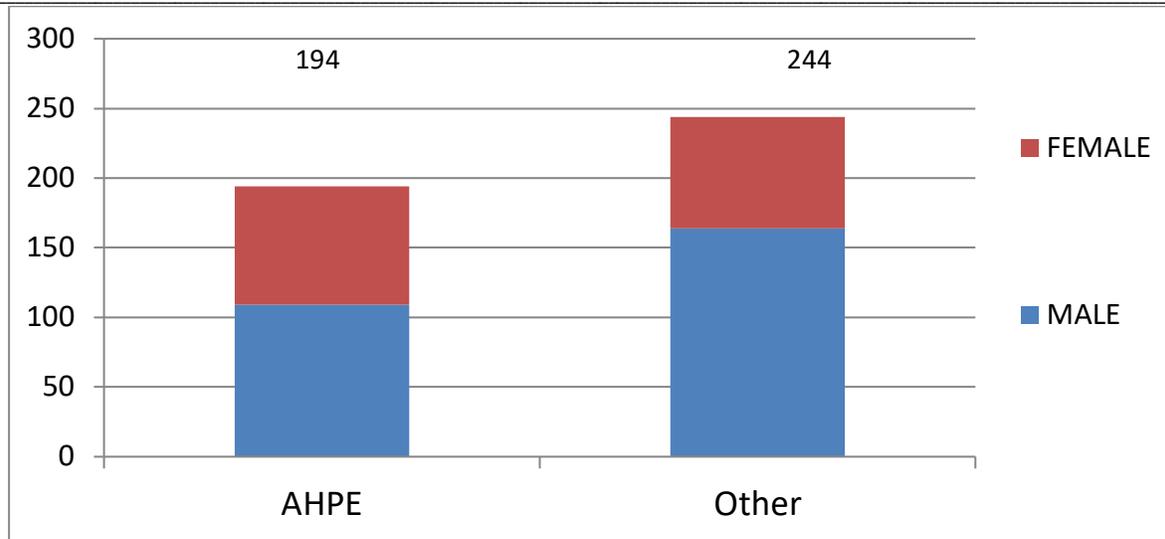


Fig 2: Distribution of groups made by thoracic USG (with male-female division)

Table 6: Distribution of co-morbidities in AHPE/B-Profile group and other group

Co-morbidity	Group	
	AHPE/B-Profile	Other
Diabetes	110	128
Hypertension	125	156
COPD	61	114*
Ischemic Heart Disease	58	71
CKD	50	60
CVA	10	13

*-> P value = 0.00036

History of COPD was significantly less (p value = 0.00036) in patient of the acute hemodynamic pulmonary edema [AHPE / B-Profile or (B/L) Interstitial syndrome] group than the other group [Table 6].

Table 7: Distribution of SpO2 in AHPE/B-Profile group and the other group

Group	Mean	SD
AHPE/B-Profile	82.82	±13.91
Other	91.2	±8.98

P value = 0.0001

Patient in the “acute hemodynamic pulmonary edema [AHPE / B-Profile or (B/L) Interstitial syndrome] group” had statistically significant low saturation (SpO2) measured by finger tip pulse oximetry compare to “Other group” [Table 7].

Table 8: Distribution of ejection fraction [EF] in AHPE/B-Profile group and the other group

Group	Mean	SD
AHPE/B-Profile	44.28	±10.92
Other	58.80	±5.45

P value = 0.0001

Patient in the “Acute hemodynamic pulmonary edema [AHPE / B-Profile or (B/L) Interstitial syndrome] group” had statistically significant low left ventricular ejection fraction [EF] measured by 2D echocardiography compare to “other group”. Bilateral pleural effusion is more common in “Acute hemodynamic pulmonary edema group” and the numbers were 84. While only 4 case in “Other group” had B/L pleural effusion [Table 8].

Table 9: Distribution of Lactate value in AHPE/B-Profile group and the other group

Group	Mean	SD
AHPE/B-Profile	2.41	±1.91
Other	1.93	±1.67

P value = 0.0049

Patient in the “acute hemodynamic pulmonary edema [AHPE / B-Profile or (B/L) Interstitial syndrome] group” had statistically significant high lactate level which is a marker of tissue hypoxia, measured by ABG, compare to “Other group” [Table 9, 10; Fig. 3].

Table 10: Distribution of consolidation evaluated by bed side thoracic USG among the patient presented with breathlessness at emergency dept [N=438]

Group	Right		Left		Bi-Lateral		Total	
	n	%*	n	%*	n	%*	n	%*
AHPE/B-Profile	15	3.42	2	0.45	7	1.59	24	5.48
Other	23	5.35	16	3.65	11	2.51	50	11.41
Total	38	8.67	18	4.11	18	4.11	74	16.89

* All % to total 438

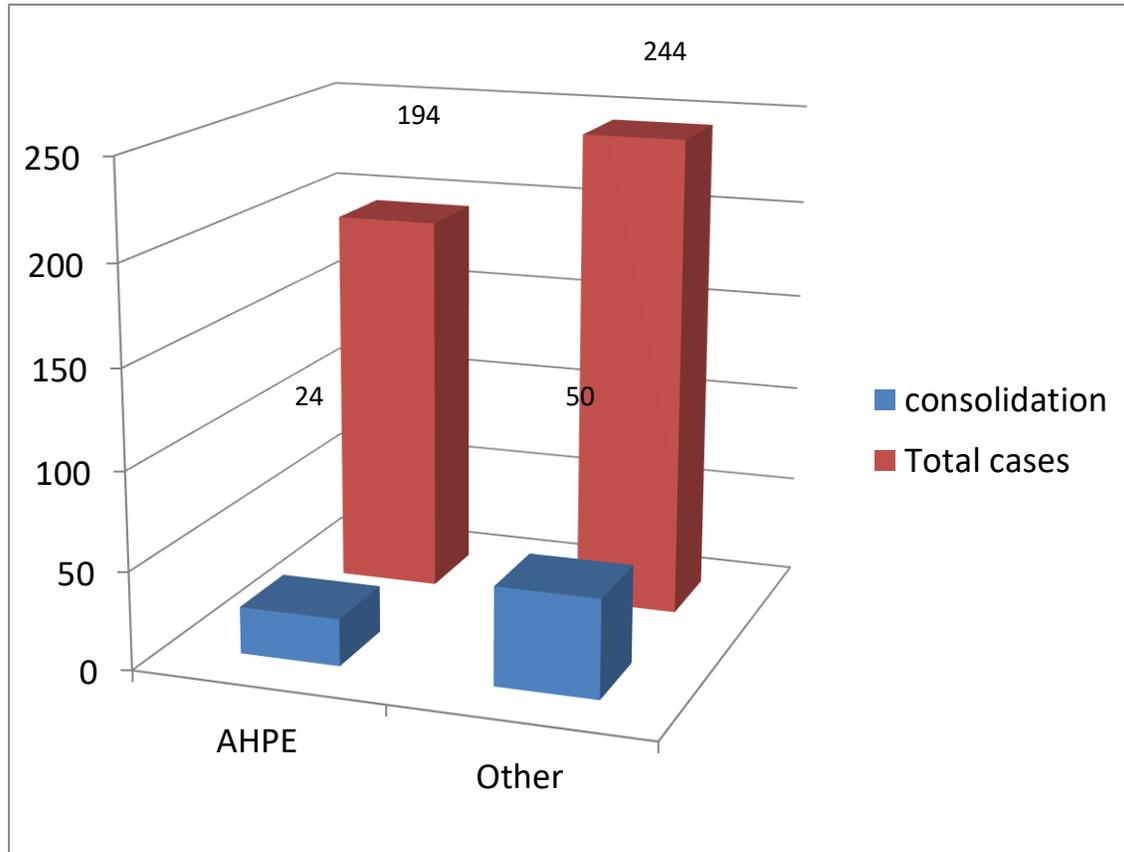


Fig 3: Distribution of consolidation found by thoracic USG

* P value = 0.02426

Total numbers of consolidation (pneumonia) found by bedside ultrasound in “Other” group was significantly higher than the “acute hemodynamic pulmonary edema [AHPE / B-Profile or (B/L) Interstitial syndrome] group”. Regarding consolidation, X-ray chest findings were well corroborated with bed side thoracic ultrasound at emergency dept [Table 11/Fig. 4].

Table 11: Distribution of consolidation as per Chest X-ray - [by silhouette sign]

Lobe involvement	Group		Total
	AHPE	Other	
Rt. Upper Lobe (RUL)	11	12	23
Rt. Middle Lobe (RML)	0	0	0
Rt. Lower Lobe (RLL)	4	11	15
Lt. Upper Lobe (LUL)	1	4	5
Lt. Lower Lobe (LLL)	1	12	13
B/L Upper Lobes (B/L-UL)	0	0	0
B/L Lower Lobes (B/L-LL)	6	5	11
B/L Multi-focal (B/L-Mf)	1	6	7

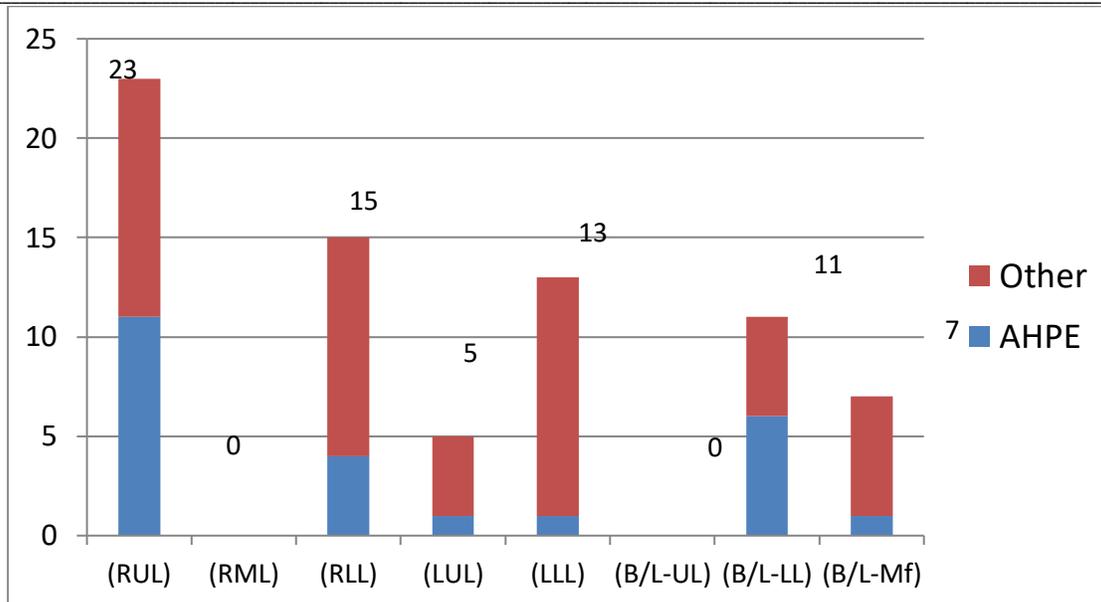


Fig 4: Distribution of consolidation as per Lobar-pattern

Mean pH and PaO2 value of the “Acute hemodynamic pulmonary edema [AHPE / B-Profile or (B/L) Interstitial syndrome] group” and the “Other” group were – [7.367 & 88.69] and [7.402 & 97.37] respectively. Numbers of patients with abnormal ECG finding were 21.

Table 12: Distribution of ECG findings

AF	PSVT	STEMI
10	3	8

Discussion

Common causes of breathlessness presenting at emergency department, include decompensated heart failure (acute hemodynamic pulmonary edema), acute exacerbation of chronic obstructive pulmonary disease (COPD), asthma, pneumonia, effusion, pulmonary embolism and myocardial infarction, arrhythmia. It is challenging to makes rapid and accurate differentiation diagnosis of the causes of dyspnea. Arterial blood gas (ABG) evaluation has been shown to perform poorly in differentiating between cardiac and respiratory causes of dyspnea [15]. The diagnostic value of B-type natriuretic peptide (BNP) and N-terminal pro brain natriuretic peptide (NT pro BNP) is used for evaluating heart failure but results for these investigations require time and may be less useful in patients with acutely worsening dyspnea who require emergent management based on initial assessment [16].

Ultrasound is becoming a more widespread tool as it is non-invasive, without ionizing radiation, cost-effective, and rapid if performed by trained clinicians at the bedside. Now, Ultrasound, particularly at the point-of-care is emerging as standard practice in emergency department in many places. Recent studies have also demonstrated its high sensitivity and specificity in the diagnosis of respiratory distress [17]. A study conducted by Lichtenstein and colleagues, a structured lung ultrasound algorithm, known as the Bedside Lung Ultrasound in Emergency (BLUE) protocol, yielded the correct diagnosis in 90.5% of medical intensive care unit (ICU) patients with acute respiratory failure [8].

Patients profile in emergency department is very heterogeneous. Differentiation between cardiac causes and respiratory cause is very important to initiate treatment. As patient with heart failure needs fluid restriction, diuresis while patient with pneumonia needs fluid resuscitation and urgent administration of intravenous antibiotics on which survival rate depends. So delay in diagnosis will leads to poor prognosis.

In this study initial clinical evaluation, ECG, bedside Ultrasound with 2D Echo were used to evaluate causes of shortness of breath. Among 438 patients, 194 were diagnosed with acute hemodynamic pulmonary edema (cardiac causes) with significant low ejection fraction (EF) [EF=44.28±10.92 (P value = 0.0001)] by 2D Echo than Others groups. These patients were also have low saturation and increased lactate level. Among these patients of hemodynamic pulmonary edema most common co-morbidity was systemic hypertension followed by diabetes mellitus. Among these patients 24 patients were also have pneumonia evaluated by lung ultrasound and chest X-ray as associated combined cause of breathlessness. Total 74 patients were diagnosed to have pneumonia and put on therapy accordingly. Arrhythmia was the cause of shortness of breath in 13 cases.

Our study had limitations. Evaluating ejection fraction alone may not be sufficient to diagnose congestive cardiac failure and assessing diastolic heart function might be necessary for a more comprehensive and thorough ultrasonographic examination evaluation such as specific measurements such as E-point septal separation and annulus measurements and measurement of BNP value.

Conclusion

About 62.33% of total patients were male. Presenting age was reported as 64.92±12.68 yrs [male - 67.73±9.84 yrs, female - 60.27±15.27yrs]. Among co-morbidities highest number of patients had Hypertension, followed by Diabetes, COPD, IHD, CKD and CVA respectively. Most symptoms associated with dyspnea was cough (77.17%) followed by chest pain (14.84%), fever (28.08%) and syncope (1.14%) respectively. Total number of the cases included in acute hemodynamic pulmonary edema (AHPE – Group) was 194 (44.29%) [Male-109 (24.88%), Female- 85 (19.40%)]. This “AHPE group” had statistically significant low ejection fraction [EF= 44.28±10.92 (P value = 0.0001)]; low saturation [SpO2 = 82.82±13.91 (P value = 0.0001) and high lactate level [2.42±1.91 (P value = 0.0049) than the “Other group”. Total numbers of consolidation (pneumonia) found by bedside ultrasound in “Other group” (n=50) was significantly higher than the “Acute hemodynamic pulmonary edema group” (n=24) [P value = 0.02426]. Right upper lobe followed by left lower lobe involvement was highest in case of pneumonia. Numbers of patients with arrhythmias were 13 [(AF-10), (PSVT-3)]. 8 of them had AMI (STEMI).

Bedside lung ultrasound is a very useful tool along with other evaluating facilities for diagnosis of acute respiratory distress at Emergency Department and to initiate rapid and prompt management.

References

- Mukerji V. Dyspnea, Orthopnea, and Paroxysmal Nocturnal Dyspnea. In: Walker HK, Hall WD, Hurst JW, editors. *Clinical Methods: The History, Physical, and Laboratory Examinations*. 3rd edition. Boston: Butterworths; 1990. Chapter 11. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK213/>
- Burki NK, Lee LY. Mechanisms of dyspnea. *Chest*. 2010;138(5):1196-1201.
- Campbell EJM. The sensation of breathlessness. *Br Med Bull*. 1963;19:36-40.
- Hsu KY, Lin JR, Lin MS, Chen W, Chen YJ, Yan YH. The modified Medical Research Council dyspnoea scale is a good indicator of health-related quality of life in patients with chronic obstructive pulmonary disease. *Singapore Med J*. 2013 Jun;54(6):321-7.
- Launois C, Barbe C, Bertin E, et al. The modified Medical Research Council scale for the assessment of dyspnea in daily living in obesity: a pilot study. *BMC Pulm Med* (12) 2012; 61.
- Patel CJ, Bhatt HB, Parikh SN, Jhaveri BN, Puranik JH. Bedside Lung Ultrasound in Emergency Protocol as a Diagnostic Tool in Patients of Acute Respiratory Distress Presenting to Emergency Department. *J Emerg Trauma Shock*. 2018;11(2):125-129.
- Lichtenstein DA, Mezière GA. Relevance of lung ultrasound in the diagnosis of acute respiratory failure: the BLUE protocol [published correction appears in *Chest*. 2013 Aug;144(2):721]. *Chest*. 2008;134(1):117-125.
- Lichtenstein DA. BLUE-protocol and FALLS-protocol: two applications of lung ultrasound in the critically ill. *Chest*. 2015 Jun;147(6):1659-1670.
- Yossef Hay O, Cohen M, Nitzan I, et al. Pulse Oximetry with Two Infrared Wavelengths without Calibration in Extracted Arterial Blood. *Sensors (Basel)*. 2018;18(10):3457.
- Oikonomou A, Prassopoulos P. Mimics in chest disease: interstitial opacities. *Insights Imaging*. 2013;4(1):9-27.
- Broder J. *Imaging the Chest: The Chest Radiograph*. Diagnostic Imaging for the Emergency Physician. 2011;185-296.
- Lichtenstein, D.A. Lung ultrasound in the critically ill. *Ann. Intensive Care* 4, 1 (2014). <https://doi.org/10.1186/2110-5820-4-1>.
- Echocardiogram (Echo). <https://www.heart.org/en/health-topics/heart-attack/diagnosing-a-heart-attack/echocardiogram-echo>
- Kosaraju A, Goyal A, Grigorova Y, et al. Left Ventricular Ejection Fraction. [Updated 2021 Jul 26]. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2021 Jan-. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK459131/>
- Berliner D, Schneider N, Welte T, Bauersachs J. The Differential Diagnosis of Dyspnea. *Dtsch Arztebl Int*. 2016; 113(49):834-845.
- Weber M, Hamm C. Role of B-type natriuretic peptide (BNP) and NT-proBNP in clinical routine. *Heart*. 2006;92(6):843-849.
- Sorensen B, Hunskaar S. Point-of-care ultrasound in primary care: a systematic review of generalist performed point-of-care ultrasound in unselected populations. *Ultrasound J*. 2019; 11(1):31.

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