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# Relevance of Bedside lung Ultrasound in Emergency protocol (BLUE protocol) in the diagnosis of lung pathology in patients with respiratory failure admitted to intensive Care Unit

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# Relevance Of Bedside Lung Ultrasound In Emergency Protocol (Blue Protocol) In The Diagnosis Of Lung Pathology In Patients With Respiratory Failure Admitted To Intensive Care Unit

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**ABSTRACT**

**Background:** Acute respirational failure is a life threatening disease that still one of leading cause for admissions of cases to the critical care units.
**Aim of The Work:** To assess the diagnostic performance of Bedside Lung Ultrasound in Emergency protocol (BLUE protocol) in cases with respiratory failures admitted to ICU.
**Patients and Methods:** This observational research had been performed in Al-Hussein university hospitals ICU. We accomplished US on successive cases admitted to the ICU with respirational failures and obtaining initial diagnosis of lung pathology using BLUE protocol comparing BLUE protocol findings on initial presentations with the ultimate diagnosing by the ICU staff. Undefined diagnostics and infrequent reasons was ruled out.
**Results:** Our study results revealed that Main A-lines plus lungs sliding specified asthma or COPD (21 cases) with 80.90% and 96.20% sensitivity&specificity respectively. Multi anterior B-lines with lungs sliding showed pulmonic-edema (22 cases) which represent 90.90% and 94.80% sensitivity&specificity respectively. A ordinary frontal profile plus thrombosis in deep veins specified pulmonic-embolism (11 cases) with 72.7% and 98.8% sensitivity&specificity respectively. frontal absent lung sliding accompanying with A-lines plus lung point diagnose pneumothorax (4 cases) with 75% sensitivity and 100% specificity. Frontal alveolar consolidations, frontal diffuse B-lines with absence lungs sliding, frontal asymmetric interstitial patterns, back consolidations or free fluid with no frontal diffuse B-lines specified pneumonia (42 cases) which represent 91.4%and 92.86% specificity& sensitivity respectively.
**Conclusion:** depending on the findings, study reveals that the BLUE protocol is a reasonable guide, suitable to be used in ICU, and help to directly diagnose manifesting diseases as ARF.

**Keywords:** *Acute respiratory failure; BLUE protocol; lung; Emergency protocol; Ultrasound.*

## INTRODUCTION

Chest-CT is nowadays considered as the golden standard not only to diagnose Pneumothorax (PTX), lungs consolidations, pleural effusions, atelectasis, and alveolar-interstitial condition but as well for leading treatment options in cases with critical illness.

But to accomplish a chest CT-scan the patient must be transported to the radiology department, which is a dangerous process requiring the existence of qualified physicians and classy cardio-respiratory monitor [1]

Ordinary lungs parenchyma isn't visualized as it is consisted mainly of air, that can scatter and impede the propagation of the US wave. The big variance in the auditory features of soft tissue and lungs rending the lungs superficial predominantly strong reflector of the US and is making a variety of echo artifacts that is showing helpful info around the lungs existing patho-physiology.[2]

Protocol of BLUE is a elementary Point of Care Ultra-sound (POCUS) investigation accomplished for un-differentiated respirational failures at the bedside directly after the physical examinations, and earlier to echo-cardiography.

The protocols are easy and take <3 min to accomplish. It examines 3 standardized points on each hemi-thorax in case with respirational failures, looking for establishment of the existence or none of: Lungs sliding, Frontal lungs rockets, Posterior/lateral alveolar/pleural syndromes (PLAPS) and non-compressible deep veins

Patho-physiologic "profile" built on standardized pattern are then built, and a tentative patho-physiologic foundation for the proposed respirational failures. The main aim of the protocol is to recommend diagnosing for respiratory failure cases.[3]

## PATIENTS AND METHODS

This observational research had been performed in Al-Hussein university hospitals ICU. We accomplished US on successive cases present in the ICU with respirational failures and obtaining initial diagnosis of lung pathology using BLUE protocol comparing BLUE protocol findings on initial

presentations with the ultimate diagnosing by the ICU staff. Undefined diagnosing and infrequent reasons excepted

After approval of local scientific and ethical committees, one hundred (100) patients with respiratory failure (acute or acute on top of chronic) examined by lung ultrasound using Bedside Lungs US (LUS) in Emergency protocol (BLUE protocol) in first 20 min. of ICU admission in less than 3 minutes without interrupting patient management then initial diagnosis of lung pathology will be done using BLUE protocol

Respiratory failure diagnosed based on Arterial Blood Gases criteria of respiratory failure requiring admission to ICU ($PO_2$<55-60 mmHg-$PCO_2$>45mmHg with pH<7.34-$SPO_2$<90% on roam air).

**Exclusion criteria:** Ages <18 yrs, cases with history of lungs tumor, cases who previous lungs operation, cases with interstitial lungs fibrosis and cases with undefined or infrequent ultimate diagnosing.

**Methods:** Patient subject to the next:

Complete clinical examination: It comprises history taking and physical examinations including vital signs [BP, HR, temp., and resp. rate] and cardiac and chest auscultations. Laboratory investigation: ABG, CBC-liver functions , kidneys function tests, CT chest with or without contrast (including high resolution CT), beside CXR, ECG, Echocardiography. Consultations requested from other departments.

Ultrasound Approach: A 2D scanner has been utilized (Philips Affiniti 50,USA) in this work, and frequency range (4–12 MHz) has been utilized for lungs visualization. Probes of frequencies from 10-12 MHz have been utilized to examine the margin of the lungs with a good resolution as in searching for 'lungs movement' and other indications of pneumothorax, while probes of low frequency are used to examine deep lungs tissue as in looking at pleural effusions and consolidations.

The ordinary Lung shows lungs a movement in rhythm with respirations at the pleural viscero-parietal line, signifying movement of the parietal pleura vs. the visceral pleura, and A-lines, these repeated transverse artifacts rising from the pleural line produced by air in sub-pleural area, which, may be intra-alveolar or free (pneumothorax), stops US propagation. Normal inter-lobular septations are not detected.

3 indications with double rsults have been evaluated, as follows.

**Artifact Analysis:** B or A -Line: The B-line is representing an object with 7 characters: a aerohydric comet-tail object; rising from the viscera-parietal line of pleura; hyper-echoic; well demonsterated; go-up indeterminately; cause disappearance of A-lines; and runing with lungs movement when lungs movement is existing. It indicate existence of both constituents with a high US resistance gradient, like air and fluid. Fluid at the interlobular septum below pleura rounded by aerated alveoli satisfies this circumstance. B-lines that is 3 or more in one sight are named B+ lines. B+ lines show interstitial condition below the pleura. Other vertical artifacts may be realized; with no B-line features.

**Lungs Sliding:** Existing or absence: Abolition happens when the parietal pleura doesn't slide versus visceral pleura (inflammatory fusions, lungs inflation losing, stop breathing, atelectasis) or is separated (pneumothorax, pneumonectomy).

**Alveolar Consolidations and/or Effusions in pleura:** present or not: effusions in pleura characteristically produce pattern that is an anechoic non-constant features. quadrangular form with a straight lower border (named the lungs line and represent visceral pleura) indicated for the diagnostics. The inspiratory movement of the lungs line to the line of pleura is named the sinusoidal signs.

**Deep venous thrombosis** was sought by means of microconvex probe. Visualizations of echoic intra-luminal thrombus or nonattendance of squeezability was counted as a diagnostic result. Examinations joint a frontal method (analyzing artifacts, lungs sliding, and alveolar consolidations), a side back search for postero-lateral alveolar/pleural syndrome (PLAPS), and venous analysis.

**End Point:** Ultimate diagnosing of lungs pathology by ICU staff.

**Statistical analysis:** relevance is calculated in term of sensitivity (TP/TP+FN),specificity(TN/TN+FP), PPV(TP/TP+FP), NPV(TN/TN+FN) and accuracy (TP+TN/TP+FP+TN+FN).Data analyzed statistically by means of SPSS-20 (IBM, USA). Descriptive data was performed for parametric data as mean±SD and range and for nonparametric data like $1^{st}$ & $3^{rd}$ interquartile range (IQR) and median, while they were applied for categorical data as numbers and percentages. Inferential analyses will be done for quantitative variables using with parametric data and Kruskall Wallis testing: for multi-group comparing in nonparametric data. Inferential analyses was performed for qualitative data by means of Chi square testing for non-dependent groups. The result has significance at $P<0.05$ and high significance at $p<0.01$.

## RESULTS

| | | Sensitivity | specificity | Positive prediction | Negative prediction |
|---|---|---|---|---|---|
| Pulmonary oedema | B profile | 20/22<br>90.9% | 74/78<br>94.8% | 20/24<br>83.3% | 74/76<br>97.3% |
| COPD + Asthma | A profile or A' without PLAPS | 17/21<br>80.95% | 76/79<br>96.2% | 17/20<br>85% | 76/80<br>95% |
| Pulmonary embolism | A profile with PLAPS +DVT or A without PLAPS +DVT or A\ without PLAPS+DVT | 8/11<br>72.7% | 88/89<br>98.8% | 8/9<br>88.8% | 88/91<br>96.7% |
| pneumothorax | A' plus lung point | 3/4<br>75% | 96/96<br>100% | 3/3<br>100% | 96/97<br>98.9% |
| pneumonia | B' profile | 5/42<br>11.9% | 58/58<br>100% | 5/5<br>100% | 58/95<br>61% |
| pneumonia | A/B profile | 5/42<br>11.9% | 58/58<br>100% | 5/5<br>100% | 58/95<br>61% |
| pneumonia | C profile | 9/42<br>21.4% | 57/58<br>98.28% | 9/10<br>90% | 57/90<br>63.33% |
| pneumonia | A profile with PLAPS | 20/42<br>47.6% | 54/58<br>93.1% | 20/24<br>83.3% | 54/86<br>62.8% |
| pneumonia | -C profile- A/B profile - A profile with PLAPS -B\ profile- | 39/42<br>92.86% | 53/58<br>91.4% | 39/44<br>88.6% | 53/56<br>94.6% |

**Table 1:** Accuracy of ultrasound profile

| | Range | | Mean | SD |
|---|---|---|---|---|
| Age | 19 | 81 | 52.25 | 17.53 |
| Systolic | 80 | 200 | 119.79 | 23.52 |
| Diastolic | 40 | 120 | 67.15 | 17.70 |
| Spo2 | 65 | 88 | 79.65 | 4.94 |
| HR | 55 | 140 | 106.39 | 20.17 |
| RR | 22 | 40 | 28.55 | 4.27 |
| Temp | 36.3 | 39 | 37.69 | 0.59 |

**Table 2:** Age and vital signs distribution among study sample

| US profile | N | % |
|---|---|---|
| A'-PLAPS | 11 | 11 |
| A-PLAPS | 12 | 12 |
| A/B | 5 | 5 |
| A+PLAPS | 30 | 30 |
| B' | 5 | 5 |
| B | 24 | 24 |
| C | 10 | 10 |
| lung point | 3 | 3 |
| Total | 100 | 100 |

**Table 3:** numbers and percentage of each lung US profile in study sample

| US diag. | N | % |
|---|---|---|
| Asthma | 5 | 5 |
| COPD | 15 | 15 |
| P oedema | 24 | 24 |
| PE | 9 | 9 |
| Pneumonia | 44 | 44 |
| Pneumothorax | 3 | 3 |
| Total | 100 | 100 |

**Table 4:** numbers and percentage of each lung US diagnosis using BLUE protocol in study sample

| final diag. | N | % |
|---|---|---|
| Asthma | 6 | 6 |
| COPD | 15 | 15 |
| P oedema | 22 | 22 |
| PE | 11 | 11 |
| Pneumonia | 42 | 42 |
| Pneumothorax | 4 | 4 |
| Total | 100 | 100 |

**Table 5:** number and percentage of each final diagnosis of lung pathology causing respiratory failure

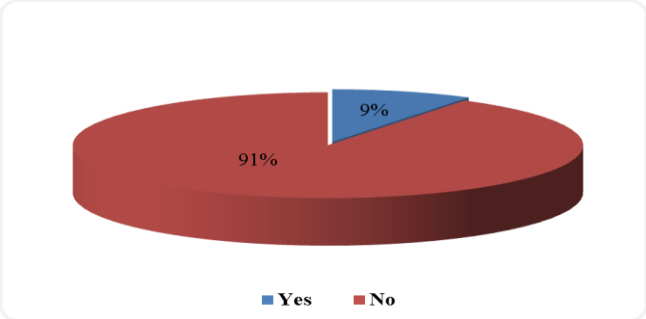


**Fig 1:** percentage of patients with and without DVT in study sample

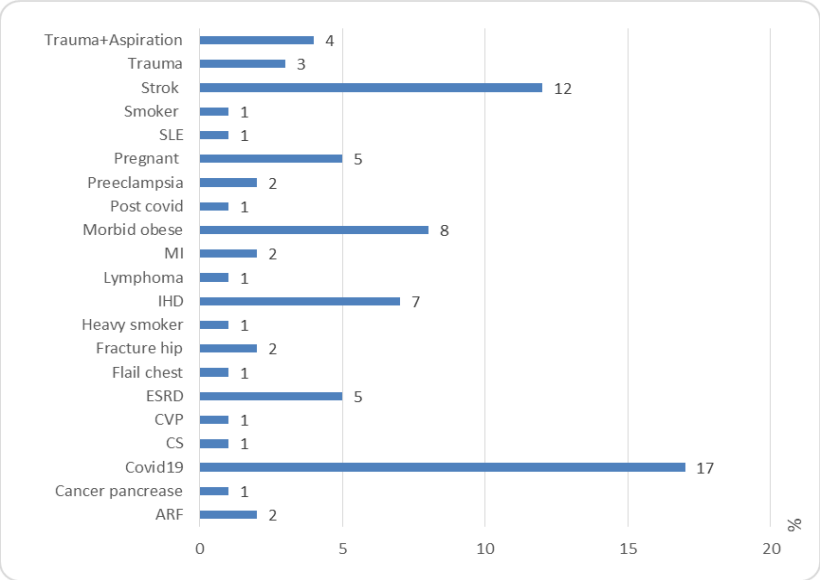


**Fig. 2:** number and percentage of associated conditions in study sample

## DISCUSSION

Acute respirational failure is a main sign of most cardiac and respirational disorders like cardiogenic pulmonary edema , obstructive condithions, community-developed pneumonia and pulmonic embolisation which are accompanied with bad prognosing.[4]

BLUE-protocol exclusively make use of venous and lung US. Its usage as a initial investigation device in the acutely dyspnea or hypoxia cases give an instant consideration to the lung condition and affects treatment decision.[5]

In this work, we aimed to assess the diagnostic performance of Bedside Lung Ultrasound in Emergency protocol (BLUE protocol) in respiratory failure patients admitted to ICU.

This observational research was performed at tertiary care at Al-Hussein university hospital ICU and performed on a number of 100 cases who admitted to the ICU with respirational failures (acute or acute on top of chronic) and obtaining initial diagnosis of lung pathology using BLUE protocol.

During this work, 112 patients were assessed for eligibility and 100 patients were selected in the study. Of all eligible cases, 12 patients were omitted from this work based on the inclusion criteria.

Ultimately, the analysis was based on the data of 100 cases enrolled to the ICU with respirational failures.

Quickly, a ordinary profile showed COPD/asthma in an acutely dyspnic case. The B-profile (frontal interstitial condition + lungs movement) showed pulmonic-oedema . The B' profile (lungs movement eliminated) showed pneumonia. The A/B profile (non symmetric frontal interstitial condition) and the C-profile (frontal consolidations) specified pneumonia, as did the A-profile with PLAPS. The A-profile along with venous thrombosis showed pulmonic embolisation. [5]

Different studies were done evaluating the accurateness of the BLUE protocol in giving a suitable diagnosing in cases presented with ARDS in emergency, some of them agree and others differ from our results.

The current research study revealed that the principal clinical diagnosis between the majority of cases was pneumonia which represented 42% of patients followed by Pulmonic-oedema (22%).

Our study results revealed that Pneumonia was detected in 42 cases. The A-profile with PLAPS, the C-profile (anterior consolidation), B' profile (lungs movement abolished) and the A / B-profile (non symmetric frontal interstitial condition) specified pneumonia.

The A-profile plus PLAPS was reported in 20 cases of pneumonia with 47.6% and 93.1% sensitivity&specificity resp. The C-profile has been reported in 9 cases with 21.4% and 98.28% sensitivity&specificity resp. Each of A/B and B' profile profile were detected in 5 cases with 11.9% and 100% sensitivity&specificity resp. Combined (A-profile with PLAPS + C-profile + B' profile+ A/B profile) profiles in 39 cases proposed pneumonia with 92.86% and 91.4% sensitivity&specificity resp. The B-profile was detected in 2 cases and Ordinary profile was detected in a single case.

Chaitra et al., [4] conducted a cross-sectional report to investigate the fundamental etiologic mechanism in 130 cases presented with ARF and admitted to the ICU in which lungs US was accomplished in accordance to the BLUE protocol.

Chaitra et al., [4] results were agreed with our results in that Pneumonia was the commonest reason of ARF detected in this work, then PE, COPD/Asthma, pneumothorax, pulmonic thromboembolism, and ARDS. Mixed profiles of A-profile + PLAPS, C-profile (frontal consolidation), A/B profile (asymmetric frontal interstitial condition) and B' profile (lungs sliding abolished) showed pneumonia and found in 37 patients out of 45 patients that finally diagnosed with pneumonia with 100% sensitivity, 91% specificity.

Patel et al., [5] conducted a study which involved a total 50 patients with acute respiratory distress to show the accurateness of the BLUE protocol in giving a right diagnosis in cases presented with ARDS in emergency.

Cases with pneumonia in Chaitra et al., [4] report presented with different profiles were defined as: B-profile (preserved lung sliding) had 8 % and 99 % sensitivity&specificity resp. in detecting pneumonia, which was agree with Lichtenstein et al., [6], who reported 14.5 % and 100 % sensitivity&specificity resp.

Patel et al., [5] revealed that the A/B profile (A-line on side and B+line on other) was reported in pneumonia with 35.29% and 96.96% sensitivity&specificity resp. the C-profile (frontal consolidation) was reported with 52.9 % and 100 % sensitivity&specificity resp and the A-profile with PLAPS diagnose pneumonia with 5.9 % and 96.9 % sensitivity&specificity resp.

In a report performed by Nazerian et al., [7] consolidations profile had 82.80% and 95.50% sensitivity&specificity resp. Agmy et al., [8] as well reported this profile to have 81% and 100% sensitivity&specificity resp.

Our research study revealed that PE was detected in 22 cases. The B-profile (principal B + lines with lungs sliding) showed PE. The A-profile + PLAPS was detected in 2 cases and showed PE. B-profile was reported in 20 cases with 90.90% and 94.80% sensitivity&specificity resp.

Chaitra et al., [4] revealed that B-profile with preserved lung sliding was detected in all 28 cases of pulmonic-oedema with 100%, 94.0% and 89.23% sensitivity, specificity and accuracy of detecting pulmonic-oedema. The BLUE protocol performed at admissions exhibited good conformity with the ultimate diagnostics with a diagnostic accurateness of 95.4%.

Consequently, all cases with pulmonic-oedema had preserved lungs sliding, and consequently no presence of lungs movement had 100 % specificity in presiding out pulmonic-oedema. The B-profile detects pulmonic-oedema with elevated accurateness. [4]

Patel et al., [5] revealed that the B-profile (principal B + lines with lungs sliding) was detected in 12 cases of PE with 92.30% and 100% sensitivity&specificity resp.

Our study results revealed that COPD/Asthma was detected in 21 cases. The A or A' profile with no PLAPS (principal A-line with lungs sliding) showed COPD/asthma. The A' profile was detected in 17 cases with 80.90% and 96.20% sensitivity&specificity resp. In a single person, A-profile plus PLAPS was observed and in 2 patients, B-profile was detected.

Chaitra et al., [4] revealed that COPD shaped the detection for 17 cases, in which 13 patients showed frontal-predominant bi-lateral A-lines with lungs sliding and no PLAPS (ordinary profile) with 76% and 85% sensitivity&specificity resp. while frontal-predominant bi-lateral B-lines were existing in single person, and PLAPS was detected in 2 patients. BLUE protocol had a total diagnostic accurateness of 96.9% in the detection of COPD.

Patel et al., [5] revealed that the A-profile (principal A-line with lungs sliding) was detected in 14 cases of COPD with 85.2% and 88.9% sensitivity&specificity resp.

Our study results revealed that pulmonary embolism was detected in 11 cases. The A-profile with PLAPS +DVT or (A or A' without PLAPS) +DVT were detected in 8 cases with 72.70% and 98.80% sensitivity&specificity resp. The C-profile was detected in single person.

Chaitra et al., [4] revealed that thirteen patients were diagnosed with pulmonary thromboembolism and twelve patients had venous thrombosis. All cases had frontal-predominant lines with lungs sliding. Predominant frontal bi-lateral A-lines + venous thrombosis principle had 92% and 100% sensitivity&specificity resp. with an agree with BLUE diagnosing protocol, with an general diagnostic accurateness of 99.2% US.

Consequently, the non-presence of both lungs movement and B-lines was detected in all patients of pneumothorax, thus making a 100 % specificity.

Patel et al., [5] revealed that the A' profile (principal A-line with no lungs sliding) with lungs point was found in patients with pneumothorax with 80% sensitivity and 100% specificity.

**Limitations**

LUS require training and reliability depend on experience of the ultrasonographer. Also patient dependent factors such as obesity, the existence of subcutaneous emphysema and wound dressing alter the transmission of ultrasound beams and make ultrasound assessment challenge.

Also BLUE protocol reach to single diagnosis and in practice there is mixed conditios affecting the treatment planes like COPD patient with pneumonia the BLUE protocol give diagnosis of pneumonia and neglect COPD which important to modify treatment.

## CONCLUSION

according to the findings, this work reveals that the BLUE protocol is a reasonable aid, suitable for use in ICU, and help to directly diagnose manifesting diseases as ARF.

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