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Role of chest ultrasound to differentiate between acute cardiogenic pulmonary edema and non-cardiogenic pulmonary edema (acute respiratory distress syndrome)

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Abstract

Introduction Chest Ultrasound can help in rapid treatment of acute respiratory failure in intensive care units when rapid decisions are needed and especially when patients' transport is a big difficult. Therefore, CUS can be considered an attractive complementary diagnostic tool and one of the most promising techniques for differentiation and management of critically ill patient with either acute cardiogenic pulmonary edema (APE) or acute respiratory distress syndrome (ARDS). Aim :This study was aim to clarify the role of chest ultrasonography to differentiate between ARDS(Acute respiratory distress syndrome) and Acute cardiogenic pulmonary edema in patients admitted to ICU with acute dyspnea. Patients and methods Lung US was applied to respiratory distressed patients In Benha University Hospital ICUs on 60 patients who divided into APE group (23 cases) or ARDS group (37 cases). LUS examination focused on detecting the following pleuropulmonary signs in both groups: alveolar–interstitial syndrome(AIS), absent or reduced lung sliding,spared areas ,subpleural consolidation pleural line abnormalities, and pleural effusion. Result Alveolointerstitial syndrome (AIS)was observed in 100% of APE patients and in100% ofARDS patients . Absent or reduced lung sliding was observed in 0% of APE patients and in 97.3% of ARDS patients(P=0.001). spared areas were found in 0% of APE patients and100% in ARDS patients(=0.001),lungConsolidations were present in 4.3% of APE patients in 94.6% of ARDS patients with (P=0.001). Pleural line abnormalities were observed in 13% of APE patients and in 100% of ARDS patients(P=0.001),and Pleural effusion was present in 100% Of APE patients and in 40.5% of ARDS patients with APE (P=0.001). All these signs, except the AIS sign,presented a statistically significant difference in differentiation between ARDS and APE, resulting in specific ultrasonographic pleuropulmonary signs of ARDS and APE. Conclusion Results of the current study demonastrated that LUS play asignificant role in management of respiratory failure patients especially cases of ARDS and APE in ICU by helping in rapid diagnosis and differentiation between both types in accompanying with EChocardiodraohy and IVC diameter measurement. Absence of reduced lung sliding,spared areas,suppleural consolidation, pleural line abnormalities, on a background of AIS considered specific features for differentiation between ARDS and APE.

Keywords: acute cardiogenic pulmonary edema, acute respiratory distress syndrome, lung ultrasonography, chest ultrasound.

1. Introduction

Acute respiratory failure 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 compromises outcome [1].

ARDS may be differentiated from cardiogenic pulmonary oedema using lung ultrasound(LUS)on the basis of inhomogeneous interstitial pattern, pleural line changes and presence of lung consolidation [2], with US interstitial syndrome diagnostic accuracy of 95% when compared to CT-defined ARDS [3].

ARDS can be diagnosed once cardiogenic pulmonary oedema and alternative causes of acute hypoxemic respiratory failure and bilateral infiltrates have been excluded. ARDS diagnosis based on The Berlin Definition (4, 5, and 6):

- Respiratory symptoms must have begun within one week of a known clinical insult, or the patient must have new or worsening symptoms during the past week.
- Bilateral opacities consistent with pulmonary oedema must be present on chest radiograph or computed tomography (CT) scan.

The patient's respiratory failure must not be fully explained by cardiac failure or fluid overload. An objective assessment (e.g, echocardiography) to exclude hydrostatic pulmonary edema is required .

A moderate to severe impairment of oxygenation must be present, as defined by the ratio of arterial oxygen tension to fraction of inspired oxygen (PaO2/FiO2).

Acute respiratory distress syndrome (ARDS) has traditionally been caused by a variety of insults as sepsis, which considered the most common cause of ARDS[7].

On the other hand cardiogenic pulmonary oedema is defined as pulmonary edema due to increased capillary hydrostatic pressure as a result of cardiac dysfunction, The differentiation between ALI/ARDS and CPE is important in order to avoid delaying treatment of fluid retention

This study was aim to clarify the role of chest ultrasonography to differentiate between ARDS(Acute respiratory distress syndrome) and Acute cardiogenic pulmonary edema in patients admitted to ICU with acute dyspnea**.**

2. Patients and methods

This cross sectional prospective study was carried out in the Intensive care units at Benha University Hospital to clarify the role of chest ultrasonography to differentiate between ARDS and acute pulmonary edema to allow proper management in both cardiac and non cardiac one.In the period between December 2019 till November 2021 Patients were eligible for participation in this study if they had received a new diagnosis of acute respiratory faliure .ABG testing was ordered within ICU admission, showed aPao 2 /Fio 2 ratio less than 300. patients dividing into two groups,ARDS group who admitted and fulfilling criteria of Berlin ARDS definition .

In addition, APE group who diagnosed on the basis of clinical signs and symptoms, ECG, chest radiography, and echocardiography.As LUS is now part of routine diagnostic procedures inour unit, no informed consent or approval of ethics committee were requested.All patients underwent LUS on admission and after being diagnosed based on clinical and radiological data.

Regarding the probes used we have two probes
Alinear array operates between 6 to 12MHz

Curvilinear array operates between 4 to 5 MHz transducer ultrasound machine:[Sonoline GE Logiq F8 ultrasound machine optional features (static elastrography, LOGIQ View,made in India) at the general ICU of Benha University Hospital was used for lung examination.

The examination was performed at patient bedside. Lateral or seated positions were used to scan the posterior thorax. In patients in whom the seated position was not possible, a lateral decubitus position was used to examine posterior lung regions .

Probes were placed vertically along each intercostal space (the parasternal line, anterior axillary line, and posterior axillary line) on both sides. Data were displayed on a screen. Each hemithorax should be divided into five zones: two anterior zones separated by the third intercostal space, two lateral zones, and one posterior zone .

The following ultrasonographic signs were investigated in this study to differentiate between ARDS and APE:

- Alveolointerstitial syndrome (AIS) defined as the Presence of more than3 Ultrasound lung comets means (B lines) or "white lung" appearance for each examined area.
- pleural line sliding was defined as evidence of pleural movement; indicates a pulmonary region in contact with the thoracic
- wall and excludes pneumothorax,which may be absent or reduced in acute lung injury ,lobar consolidation and atelectasis
- Pleural lines abnormalities defined as thickening greater than 2mm, evidence of small sub pleural consolidations or coarse appearance of the pleural line its presence means a process either consolidations or inflammatory process as in cases of ARDS,ALI and its absence means acute process as in (APE).
- Pleural effusion which appeared as anechoic areas limited by diaphragm.
- Spared areas which are normal areas of the lung surrounded by areas of AIS.
- Subpleural consolidation,Air bronchogram which are appear mainly in cases of ARDS appear as comet tail appearance.

B profile is the main diagnostic profile of our study which means presence of more than 3 Blines in the scanned field in two zones bilaterally by applying BLUE Protocol as all of our patients were critically ill dyspenic patients.

In this study Patients divided into Non Cardiogenic group37 patients and cardiogenic group ,23patients

Non cardiogenic group were selected by preceded history of infective causes and other causes as malignancy of ARDS.

Most common affected cases of infective causes were COVID swab +ve represent 56,8%of all ARDS cases.

Cardiogenic-pulmonary oedema group: who were preliminary diagnosed by Echocardiography, history and examination.

Statistical Methods

Data were collected, revised, then extracted and coded in excel file. The coded data were analyzed using Statistical package for Social Science (SPSS) version 26.

The analyzed data was presented in suitable tables and graphs using mean ± Standard deviation (SD) for continuous variables, and frequency and percentage for categorical variables.

Independent 2 samples t-test was used to analyze continuous variables differences across independent two groups, and Chi-Square test was used to examine the relationship between two qualitative variables. Fisher's exact test was used to examine the relationship between two qualitative variables when the Chi-square test assumptions were violated (the expected count is less than 5 in more than 20% of cells)

To estimate the prediction ability of US parameters to pulmonary edema natural and compare between them, the following indicators were calculated: Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV) , and accuracy.

Additionally, the receiver operating characteristic (ROC) curve was drawn for each parameter, the area under the ROC curves were calculated, and the statistical differences between the area under the ROC curves and 0.5 were calculated and tested for significance.

All tests of significance were conducted at 0.05 level of significance.

3. Results

The study included 60 patients. 37 met the criteria of ARDS and 23 had APE. There were 36 male and 24 female patients. The demographic characteristics of studied patients are shown in Table 1,2

Demographic analysis in both group

Table (1) comparison between the two groups as regard personal data.

	Noncardiogenic (n=37)		**Cardiogenic (n=23)**		**p-value**
Sex, no., %					
Male	21	56.8	15	65.2	0.52
Female	16	43.2	8	34.8	
Age, mean ±SD	38.86	±16.41	63.26	±11.38	<0.001*

Table (2) Demographic characteristics of study population as regard clinical history.

	Noncardiogenic (n=37)		Cardiogenic (n=23)		p-value
	No.	%	No.	%	
DM					
Yes	5	13.5	12	52.2	0.001*
No	25	86.5	9	47.8	
HTN					
Yes	3	8.1	20	87	<0.001*
No	34	91.9	3	13	
IHD					
Yes	4	10.8	19	82.6	<0.001*
No	33	89.2	4	17.4	
Sepsis					
Yes	21	56.8	4	17.4	0.003*
No	16	43.2	19	82.6	
Aspiration					
Yes	7	18.9	0	0.0	0.037 F*
No	30	81.1	23	100	
Pneumonia					
Yes	21	56.8	0	0.0	<0.001*
No	16	43.2	23	100	
Malignancy					
Yes	5	13.5	0	0.0	0.15 F
No	32	86.5	23	100	

In the demographic and comorbid data comparison between the study groups, It was found that the diabetes, hypertension and IHD were significantly higher among cardiogenic pulmonary edema patients compared to noncardiogenic patients.

On the other hand, sepsis, pneumonia, and aspiration rates were significantly higher among noncardiogenic pulmonary edema patients compared to cardiogenic patients.

Table (3) Comparison between ARDS group and cardiogenic group as regard laboratory findings.

	Noncardiogenic (n=37)		Cardiogenic (n=23)		p-value
	Mean	SD	Mean	SD	
P/F ratio	158.89	64.604	194.43	70.517	0.05*
WBC	14.243	7.3273	9.022	6.9191	0.008*

Additionally , WBC count was higher in noncardiogenic group than cardiogenic,while P/F ratio was higher in cardiogenic group than cardiogenic one.

Table (3) Comparison between acute respiratory distress syndrome and acute cardiogenic pulmonary edema cases as regards lung ultrasonographic findings.

	Noncardiogenic (n=37)		Cardiogenic (n=23)		p-value
AIS, no., %					
Yes	37	100	23	100	NA
No					
Reduced Pleural sliding, no., %					
Yes	36	97.3	0	0.0	<0.001*
No	1	2.7	23	100	
Pleural line abnormalities, no., %					
Yes	37	100	3	13	<0.001*
No	0	0.0	20	87	
Sub pleural consolidation, no., %					
Yes	35	94.6	1	4.3	<0.001*
No	2	5.4	22	95.7	
Pleural effusion, no., %					
Yes	15	40.5	23	100	<0.001*
No	22	59.5	0	0.0	
Spared areas, no., %					
Yes	37	100	0	0.0	<0.001*
No	0	0.0	23	100	
IVC mean ±SD	1.430	.2933	2.370	.4247	<0.001*

The sensitivity and specificity of each ultrasonographic sign in ARDS and APE, are illustrated in Table(4)

Table (4) Ultrasound-based predictors for noncardiogenic pulmonary edema.

	Sensitivity	Specificity	PPV	NPV	Accuracy
Reduced Pleural sliding	97.3	100	100	95.8	98.3
Pleural line abnormalities	100	87	92.5	100	95
Sub pleural consolidation	94.6	95.7	97.2	91.7	95
No pleural effusion	59.5	100	100	60.5	75
Spared areas	100	100	100	100	100
IVC diameter < 1.95	97.3	95.7	97.3	95.7	96.7

Ultrasound parameters including 5 indices were significantly different between the study groups and each one of could be used as an independent parameter given its sensitivity and selectivity

The comparison above showed that the spared areas had the highest accuracy followed by the reduction in pleural sliding.

IVC with a cutoff point of ≥ 1.95 was a significant predictor for cardiogenic pulmonary edema. Values < 1.95 were indicative for noncardiogenic pulmonary edema with a sensitivity and specificity of 97.3 and 95.7% respectively.

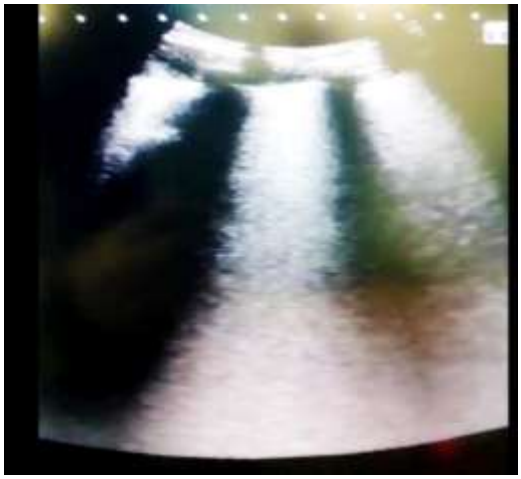

Fig. (1) AIs in both groups,but homogeneous in APE

Fig. (2) show pleural effusion and air bronchogram، in ARDS

Fig. (3) spared areas in between AIS characteristic for ARDS

4. Discussion

Lung ultrasound is a relatively novel application of point- of-care diagnostic ultrasound in acute care. It is non- invasive, rapid and relatively easy to perform and, as such, it bridges the gap between clinical examination and other time consuming investigations, helping to guide patient management in a number of clinical scenarios. It has the potential to significantly reduce time to correct diagnosis, harmful radiation, risk of transport and cost.

In the current study both groups cardiogenic and non cardiogenic were charachterized by AIS (alveolar interstitial syndrome)which is characterized by multiple diffuse vertical artifacts (B-lines), and correlates with extravascular lung water by 100% .

This was agree with the study of Taher Elnagarr et al[8].on 2016 which done on28 patient .Agreement also with Daabis et al.[9] on2014 ,study on 100 pateint 10% of them was diagnosed as ARDS also show that AIS was found in all of them.

In the current study absence of pleural sliding was found in94.6%in non cadiogenic group,and 4.3%in cardiogenic group.Agreement with the study of Taher Elnagarr et al.on 2016 that found reduction or absence of pleural sliding in all ARDS patients in his study,this also agree with copetti et a[10].on 2008 on 58 patients ,Absence or reduction of the 'gliding sign' was observed in 100% of patients with ALI/ARDS and in 0% of patients with APE.

In the current study pleural line abnormalities were detected in 100%of non cardiogenic group and0%of cardiogenic group.The result was matching with ELnagarr et al. study on 2016which detect pleural line abnormalities in 100% of patients with ALI/ARDS and in 0% of patients with APE.Also copetti et al.on.[10] 2008 on 58 patients Pleural line abnormalities were observed in 100% of patients with ALI/ARDS and in 25% of patients with APE ($p < 0.0001$). In the current study Subpleural consolidation in 94.6% of non cardiogenic group&4.3%<0.001

which was nearly comparable to that reported by

Zanobetti et al. [11], InAgreement with A.Sanjan et al.[12] on 2019 on 73 respiratory distressed patients found that consolidation were present in moderate (100%)and sever(92.3)% ARDS.

In the current study spared areas(areas of normal lung in betweenB lines found in 100%of non

cardiogenic group and 0%of cardiogenic group this sign had the highest accuracy followed by the reduction in pleural sliding and subpleural consolidation.

In agreement with Copetii et al.on 2008 on 58 patients 'Spared areas' were observed in 100% of patients with ALI/ARDS and in 0% of patients with APE ($p < 0.0001$).

In the current study the spared areas had the highest accuracy followed by the reduction in pleural sliding as its sensitivity and specificity 100%

Pleural effusion in the current study represents 40.5%of non cardiogenic group&100%of cardiogenic group ,pleural effusions were more frequently seen in APE than in ARDS .Absence of Pleural effusion has Sensitivity of59.5%& Specificity 100%Similar results were reported by Copettiet al.on 2008. and Kataoka et al. [13]

5. Conclusion

Results of the current study show that using lung US in Differentiation between ARDS and APE through the Characterestic pleuropulmonary signs as spared areas of AIS, reduced lung sliding , subpleural consolidation and pleural effusion add ahigh value in the clinical field regarding early diagnosis and management of respiratory failure patients, especially in ICU،also using lung ultrasound saves time and decreases the need for CT,whose drawbacks include delayed Care implementation ,irradiation and high Feasibility.[3]

Reference

[1] P. Ray, S. Birolleau, Y. Lefort, Acute respiratory failure in the elderly: etiology, emergency diagnosis and prognosis. Crit Care. Vol.10:R82,2006.

[2] R. Copetti, G. Soldati, P. Copetti, Chest sonography: a useful tool to differentiate acute cardiogenic pulmonary edema from acute respiratory distress syndrome.

[3] D. Lichtenstein, N.lascols, Meziere p.G,Bideman. Comparative diagnostic performances of auscultation, chest radiography, and lung ultrasonography in acute respiratory distress syndrome, Anesthesiology.vol.100 (1),pp. 9–15,2004.

[4] C.Guerin, F.Bayle, V.Leray. Open lung biopsy in non resolving ARDS frequently identifies diffuse alveolar damage regardless of the severity stage and may have implications for patient management. Intensive Care Med.vol. 41,pp.222,2015.

[5] ND.Ferguson, E.L.Fan. The Berlin definition of ARDS: an expanded rationale, justification, and supplementary material. Intensive Care Med .vol. “38,pp.1573. 2012.

[6] G.Soldati, R.Inchingolo, A.Smargiassi, S.Sher. Ex vivo lung sonography: morphologic-ultrasound relationship. Ultrasound Med Biol.vol. 38(7),pp.1169-1179. Doi: 10.1 016 /j.ultrasmedbio,03.001,2012.

[7] R.Iscimen, R.Cartin-Ceba, M.Yilmaz. Risk factors for the development of acute lung injury in patients with septic shock: an observational cohort study. Crit Care Med" 2008.

[8] Taher El-Naggara , Samar H. Sharkawya , Hossam Mohamed Abdel-Hamida , Haitham S. El-Din Mohamada , Rasha Mustafa A. Mohamedb Egypt J Bronchol 2016 10:319–323 © 2016 Egyptian Journal of Bronchology Egyptian Journal of Br

[9] R.Daabis , L.Banawan, A.Rabea, El.Abdelaziz , S.Ayman, review articleRelevance of chest sonography in the diagnosis of acute respiratory failure: Comparison with current diagnostic tools in intensive care units, Egyptian J of Chest Dis and Tubercu.vol.63,pp.979-85,2014

[10] R.Copetti, G.Soldati, P.Copetti: Chest sonography: a useful tool to differentiate acute cardiogenic pulmonary edema from acute respiratory distress syndrome. Cardiovasc Ultrasound.vol. 6,pp. 16. 10.1186/1476-7120-6-16,2008.

[11] Zanobetti, Maurizia . Can chest ultrasonography replace standard chest radiography for evaluation of acute dyspnea in the ED?” Chest.vol. 139,pp. 1140-1147,2011.

[12] A.Sanjan ,S.Vimal Krishnan ,Siju V.Abraham, et al utility of point of care ultrasound for initial assessment of ARDS Patients in emergency department J EMERG Trauma shock . Oct-Dec .vol.12(4),pp.248-253. Article pubReader cite, 2019.

[13] H.Kataoka, S.Takada. The role of thoracic ultrasonography for evaluation of patients with decompensated chronic heart failure. J Am Coll Cardiol.vol. 35(6),pp.1638–1646,2000.