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The role of Combined cardiac and lung ultrasound in acute respiratory distress Running title: cardiac and lung ultrasound and respiratory distress

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ORIGINAL ARTICLE

The Role of Combined Cardiac and Lung Ultrasound in Acute Respiratory Distress

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Abstract

Background: **Patients referred to the intensive care unit (ICU) often appear with the life-threatening condition known as acute respiratory distress &/failure (ARF), but the standard methods of diagnosis, with the exception of computed tomography (CT) chest, have poor accuracy. Ultrasound (US) performed at the patient's bedside is quickly gaining acceptance as a reliable method for real-time evaluation of the heart and lungs.**

Our study aim to assess the value of combined cardiac and pulmonary ultrasound (CPUS) in determining the aetiology of ARF in critical ill patients.

Patients and methods: **In this observational, prospective investigation, adults in the ICU who was included had a CPUS performed on them at the time of diagnosis. Each patient's initial clinical diagnosis was compared to the patient's post-US clinical diagnosis.**

Results: **After tallying the data, 50 patients met the criteria for inclusion. Mean age was 51 ± 17.9 standard deviations (SD), and male: female was 18 (36%): 32 (64%) respectively. Use of LUS changing or adding to primary aetiological diagnosis by 84% especially within group of HTN with *P* value 0.059. When we use echocardiography we changing or adding to primary aetiological diagnosis by 99%, especially in male and AKI subgroups with $P = 0.032$ and 0.22 respectively. Across the subgroups determining lung causes, cardiac causes or combined causes of RF by CPUS was significantly different in DM, CKD, AKI subgroups by $P = 0.022$, 0.25, and 0.011, respectively.**

According to our research, routine CPUS screening of ARF patients upon ICU admission is practical and has a great significance on diagnosis.

Keywords: Causes, Echocardiography, Lung ultrasound, Respiratory distress&/ failure

1. Introduction

Patients hospitalized to the intensive care unit often come with the life-threatening condition of acute respiratory distress and/or failure (ARF) (ICU). Which is a diverse syndrome characterised by hypoxemia, hypercapnia, or both as a consequence of dysfunctional respiratory muscle function or pulmonary impairment, and which is described in Refs. 1–3 acute respiratory distress syndrome (ARF) may be either hypoxic (SaO_2 90% with normal $PaCO_2$) or hypercapnic ($PaCO_2$>45 mm Hg).[3] Acute respiratory failure may have several causes, including neuromuscular disorders, airway obstruction, alveolar diseases (either localized, such as pneumonia, or widespread, as in cardiogenic pulmonary edema [CPE]), interstitial illnesses, vessels disorders such metabolic issues and pulmonary embolism.[4] ICU patients with ARF present diagnostic challenges; nonetheless, early detection and management of specific causes is crucial and has a significant influence on morbidity, discharge and mortality.[4] Diagnostic procedures that have been

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used for many years include taking a patient's medical history, doing a physical examination, analysing arterial blood gases (ABGs), taking x-rays, and (CT). The reliability of a physical examination is minimal.[5,6] However, the aetiology of ARF cannot be fully determined by an ABG examination.[7] The diagnostic value of chest X-rays (CXRs) taken at the bedside is minimal.[5] CT offers excellent diagnostic accuracy, but it has a number of drawbacks that make it unsuitable for use on critically sick patients. These include the danger of radiation exposure, the high cost, and the inadequacy of getting such patients to a scanning room.

It has recently come to light that bedside ultrasonography (US) may be a useful tool for dynamic evaluation of the lungs and heart. Bedside US is superior to examination and CXR for diagnosing chest problems in ICU patients because it is easily accessible, noninvasive, easy, cost-efficient, and may be repeated at whim.[5,6,8] Recently, transthoracic echocardiography (TTE) and lung ultrasound (LUS) have been combined into a single integrated approach that have a role in determining the aetiology of ARF.[9] Not employed in all instances of ARF, not well known to certain clinicians, and incompatible with other specialisations are only a few of the drawbacks that reduce its utility in clinical practise. Our purpose in our study we examine the diagnostic value of combined lung and heart critical care ultrasound in detecting Acute Respiratory Distress and/or Failure causes in critical ill patients.

2. Patient and methods

The adult patients who were admitted to the Medical Intensive Care Unit (MICU), Internal Medicine Department, Al Hussein University Hospital, Al Azhar University, during the period of Jan 2019 to Jan 2020, were the subject of this prospective observational study. Patients with ARF or those who had been hospitalized to the ICU for another cause but later developed ARF during their hospital stay were prospectively recruited. Inclusion criteria include patients 18 years old or more who develop one or more of ARF criteria, including saturation oxygen (SaO_2)≤94% in non-COPD patients or (SaO_2) ≤90% in patients having COPD in room air, 25 rate of respiration or more in a minute, an arterial $PaCO_2$ of >45 mm Hg with pH < 7.35, PaO_2/FiO2 ratio of ≤200 mm Hg were included. Patients were excluded from our trial if a ICU clinician rejected bedside CPUS because it was thought to interfere with the study., After the ABG test, a sonographer was not accessible for 24 h.

Ethical considerations: This clinical investigation was carried out in compliance with the Helsinki Declaration after receiving approval from the research ethics committee of the faculty of medicine at Al-Azhar University.

Clinical evaluation include: Patient history; examination findings; 12-lead ECG; Arterial ABG on room air; x-ray chest; and basic lab including (CBC, liver function, renal function and electrolyte tests) were performed.

Echocardiography: Examination include assessment of systolic function,[10] diastolic function using standard technique,[11] and detection of pericardial effusion and masses or major heart problems.[12]

Lung Ultrasonography: One operator will analyse the lung ultrasound results without being informed of the CT and CXR results. The scanning of the anterior and lateral chest walls on both sides, while the patients were supine or semirecumbent was one of eight region/zone approaches used.[13,14] Eight of these sonographic patterns (Table 1), with a 90.5% overall accuracy, indicate critical respiratory illnesses.[8]

2.1. Statistical analysis

Mean and standard deviation were used to describe continuous variables (SD). Pearson's chi-square asymptotic test was used for comparing groups based on categorical variables in the main

Table 1. The eight profiles of the BLUE protocol and their clinical interpretation.[8]

BLUE protocol profile	Profile description	Aetiology of respiratory failure
A-profile	Anterior lung sliding + A-lines + free veins	Exacerbated COPD or Severe acute asthma
B-profile	Anterior lung sliding + lung-rockets	Pulmonary edema
B'-profile	B-profile + abolished lung sliding	
A/B-profile	Half A-profile at one lung, half B-profile at another	Pneumonia
C-profile	Anterior lung consolidation	
A-V-PLAPS profile	A-profile + free veins + PLAPS	
A-DVT profile	A-profile + DVT	Pulmonary embolism
A'-profile	A-profile + abolished lung sliding (+lung point)	Pneumothorax

BLUE, bedside lung ultrasound in emergency; COPD, chronic obstructive pulmonary disease; DVT, deep venous thrombosis; PLAPS, posterolateral alveolar and/r pleural syndrome.

analysis, whereas Fisher's exact test was used to compare groups with less than five participants. Kappa techniques and the Maknamar test for correlation were used to determine the level of agreement between subsets. There were no 1-tailed tests used in the analysis. Statistical significance was assumed when the *P* value was greater than 0.05. SPSS 23 for Windows was used to do the statistical analysis (SPSS, Chicago, IL).

3. Results

Out of the 74 patients with ARF during the time of study only 50 patients enrolled in the study over the time of study, due to patient's problem or unavailability of investigator or US scan was not possible or incomplete. Five patients had multiple etiological diagnoses for ARF, and two patients had miscellaneous diagnoses.

Analysis of 50 patients who were taken into account. There mean age Age 51 ± 17.9 years (standard deviation) ranging from 18 to 81 years, male to female was 18 (36%): 32 (64%), respectively. The history, clinical examination, and investigations were completed at the time of inclusion (Table 2), and the primary diagnosis was recorded.

Table 2. Descriptive History and relative clinical data among study group.

Variable	NO (%) OR Mean ± SD
Diabetes	
No	34 (68%)
Yes	16 (32%)
Hypertension	
No	27 (54%)
Yes	23 (46%)
Chronic Heart Disease	
Yes	4 (8.0%)
No	46 (92.0%)
Chronic Kidney Disease	
Yes	16 (32.0%)
No	34 (68.0%)
Acute Kidney Disease	
Yes	13 (26.0%)
No	37 (72.0%)
Chronic liver Disease	
Yes	2 (4.0%)
No	48 (96.0%)
Acute Liver Disease	
Yes	2 (4.0%)
No	48 (96.0%)
Systemic Lupus	
Yes	12 (24.0%)
No	38 (76.0%)
Hemoglobulin level	9.0 ± 2.69
PH	7.4 ± 0.081
Mechanical ventilation	
Yes	8 (16.0%)
No	36 (72.0%)
Disturbed conscious Level	
Yes	15 (30.0%)
No	35 (70.0%)
Mortality	
Yes	14 (28.0%)
No	36 (72.0%)

Table 3. Lung u/s in Assessment of causes of RF of the research group.

Variables	No (%)
Lung lesion cannot be detected	10 (20.0%)
Effusion in plura	3 (6.0%)
consolidation of Pneumonia/ARDS	10 (20.0%)
	Within them only 4 was ARDS
consolidation of Pneumonia in add to effusion in pleura	11 (22.0%)
	Within them only 3 was ARDS
Cardiogenic pulmonary edema	3 (6.0%)
Interstitial involvement	10 (20.0%)
	Within them only 5 was Alveolar hemorrhage (10.0%)
Interstitial involvement in add to the effusion of pleura	3 (6.0%)
chest masses Per all patients	4/50 (8%)
ARDS per all patients	7/50 (14%)

Table 3 lists the causes of RF by LUS which alter or include to essential determination by 84% (Table 4) and noteworthy relationship in HTN bunch with P esteem 0.059 (Table 5).

Table 5 lists the causes of RF determined by echocardiogram, with Preserved EF of 30 (60.0%), Mid-range EF of 6 (12.0%), and Reduced EF of 14 (28.0%). In Pt. With EF $\geq$ 50%, diastolic dysfunction was fair in (N = 30 (60%) and Grade I Diastolic dysfunction 10(33%) and no other grades can be elicited while Indeterminate diastolic dysfunction was 3 (10.0%). In PT. EF > 50% n = 20 (40%) with grade I diastolic dysfunction n = 14 (70%), grade II diastolic dysfunction n = 2 (10%), and grade III diastolic dysfunction n = 4 (20%).

Table 6 shows that 99% of primary diagnoses are altered or added by echocardiography, with male and AKI groups significantly altered (*P* values 0.032 and 0.22, respectively) (Table 5), Fig. 1.

4. Discussion

Our primary findings were (I) using both lung U/S and echocardiography early performed significantly better than standard care (examination, chest x-ray, and standard labs) to detect the aetiology of ARF in ICU; and (ii) using them early alter the primary diagnosis significantly in patients have Acute respiratory distress. Only 17% of the 50 patients with ARF included in our study had the correct initial etiological diagnosis, while LUS and TTE tests

Table 4. Echocardiography u/s in Assessment of causes of RF of the research group.

Systolic Ejection fraction	Preserved EF	30 (60.0%)			
	Mid-range EF	6 (12.0%)			
	Reduced EF	14 (28.0%)			
Myocarditis Suspicion Overall Patients	4/50 (8%)				
Pericardial Effusion Overall Patients	12/50 (28.0%)				
Infective Endocarditis Overall Patients	1/50 (2%)				
Diastolic Dysfunction (Dd)	Within patients with EF $\geq$ 50% (60% with $n = 30$)	No	17 (56.7%)		
		Indeterminate DD	3 (10.0%)		
		DD	10 (33.3%)	Grade I	10 (100%)
				Grade II	0 (0%)
				Grade III	0 (0%)
	IN PT. with EF > 50% ($n = 20$ (40%))	Diastolic dysfunction grade I	14 (70%)		
		Diastolic dysfunction grade II	2 (10%)		
		Diastolic dysfunction grade III	4 (20%)		

Table 5. Various group factors in relation to cardiac reasons of RF by echocardiography, chest causes of RF by u/s, and combination causes Numerous times and overall.

Variable	Lung causes By chest u/s		*P* value	Cardiac causes By echo		*P* value	Combined lung and cardiac causes by echo and Lung u/s		*P* value	*P* Value overall *exact test
	no	yes		No	yes		mono	bipath		
sex										
Male	6	12	0.529	1	17	0.036*	7	11	0.164	0.064*
	33.3%	66.7%		5.6%	94.4%		38.9%	61.1%		
	42.9%	33.3%		8.3%	44.7%		26.9%	45.8%		
female	8	24		11	21		19	13		
	25.0%	75.0%		34.4%	65.6%		59.4%	40.6%		
	57.1%	66.7%		91.7%	55.3%		73.1%	54.2%		
DM										
No	12	22	0.094	8	26	0.910*	20	14	0.159	0.022
	35.3%	64.7%		23.5%	76.5%		58.8%	41.2%		
	85.7%	61.1%		66.7%	68.4%		76.9%	58.3%		
Yes	2	14		4	12		6	10		
	12.5%	87.5%		25.0%	75.0%		37.5%	62.5%		
	14.3%	38.9%		33.3%	31.6%		23.1%	41.7%		
HTN										
No	11	16	0.056*	6	21	0.750	17	10	0.093	0.11
	40.7%	59.3%		22.2%	77.8%		63.0%	37.0%		
	78.6%	44.4%		50.0%	55.3%		65.4%	41.7%		
Yes	3	20		6	17		9	14		
	13.0%	87.0%		26.1%	73.9%		39.1%	60.9%		
	21.4%	55.6%		50.0%	44.7%		34.6%	58.3%		
CHD										
No	13	33	1.00*	12	34	0.560*	25	21	0.340*	0.8
	28.3%	71.7%		26.1%	73.9%		54.3%	45.7%		
	92.9%	91.7%		100.0%	89.5%		96.2%	87.5%		
Yes	1	3		0	4		1	3		
	25.0%	75.0%		0.0%	100.0%		25.0%	75.0%		
	7.1%	8.3%		0.0%	10.5%		3.8%	12.5%		
CKD										
No	11	23	0.501*	11	23	0.074*	22	12	0.015*	0.025
	32.4%	67.6%		32.4%	67.6%		64.7%	35.3%		
	78.6%	63.9%		91.7%	60.5%		84.6%	50.0%		
Yes	3	13		1	15		4	12		

(*continued on next page*)

Table 5. (continued)

Variable	Lung causes By chest u/s		*P* value	Cardiac causes By echo		*P* value	Combined lung and cardiac causes by echo and Lung u/s		*P* value	*P* Value overall *exact test
	no	yes		No	yes		mono	bipath		
	18.8%	81.3%		6.3%	93.8%		25.0%	75.0%		
	21.4%	36.1%		8.3%	39.5%		15.4%	50.0%		
AKI										
No	13	24	0.078*	12	25	0.022*	25	12	0.00*	0.01*
	35.1%	64.9%		32.4%	67.6%		67.6%	32.4%		
	92.9%	66.7%		100.0%	65.8%		96.2%	50.0%		
Yes	1	12		0	13		1	12		
	7.7%	92.3%		0.0%	100.0%		7.7%	92.3%		
	7.1%	33.3%		0.0%	34.2%		3.8%	50.0%		
SLE										
No	9	29	0.226	9	29	1.0*	18	20	0.327*	0.43
	23.7%	76.3%		23.7%	76.3%		47.4%	52.6%		
	64.3%	80.6%		75.0%	76.3%		69.2%	83.3%		
Yes	5	7		3	9		8	4		
	41.7%	58.3%		25.0%	75.0%		66.7%	33.3%		
	35.7%	19.4%		25.0%	23.7%		30.8%	16.7%		
Shock										
No	12	29	1.0*	11	30	0.425*	23	18	0.281*	0.57
	29.3%	70.7%		26.8%	73.2%		56.1%	43.9%		
	85.7%	80.6%		91.7%	78.9%		88.5%	75.0%		
Yes	2	7		1	8		3	6		
	22.2%	77.8%		11.1%	88.9%		33.3%	66.7%		
	14.3%	19.4%		8.3%	21.1%		11.5%	25.0%		
D.C. L										
No	12	24	0.295*	11	25	0.140*	23	13	0.011*	0.34
	33.3%	66.7%		30.6%	69.4%		63.9%	36.1%		
	85.7%	66.7%		91.7%	65.8%		88.5%	54.2%		
Yes	2	12		1	13		3	11		
	14.3%	85.7%		7.1%	92.9%		21.4%	78.6%		
	14.3%	33.3%		8.3%	34.2%		11.5%	45.8%		
COPD										
No	9	32	0.094*	12	29	0.092*	21	20	1.0*	0.62
	22.0%	78.0%		29.3%	70.7%		51.2%	48.8%		
	64.3%	88.9%		100.0%	76.3%		80.8%	83.3%		
Yes	9	4		0	9		5	4		
	22.0%	44.4%		0.0%	100.0%		55.6%	44.4%		
	64.3%	11.1%		0.0%	23.7%		19.2%	16.7%		
MV										
No	12	24	1.0*	10	26	1.0*	22	14	0.697*	0.89
	33.3%	66.7%		27.8%	72.2%		61.1%	38.9%		
	85.7%	80.0%		83.3%	81.3%		84.6%	77.8%		
Yes	2	6		2	6		4	4		
	25.0%	75.0%		25.0%	75.0%		50.0%	50.0%		
	14.3%	20.0%		16.7%	18.8%		15.4%	22.2%		

Overall, there are significant differences between the DM, CKD, and AKI groups in relation to the chest reasons of RF by ultrasound, the cardiac causes of RF by echocardiography, and the combined causes, with *P* values of 0.022, 0.25, and 0.011, respectively. In contrast, coupled LUS and echocardiography significantly changed the causes of RF in patients with CKD, AKI, and D. C. L., with *P* values of 0.015, 0.00, and 0.011, respectively.

modified or supplemented the basic etiological diagnosis in 84% and 99 cases, respectively. Clinical examination and CXR are less reliable than CPUS, according to earlier investigations.[6,15,16]

When patients with chronic kidney disease (CKD), acute kidney injury (AKI), and chronic cardiomyopathy (CML) were examined separately, the early combined LUS and TTE technique showed greater diagnosis accuracy in all three patient groups (*P* value 0.015, 0.00, and 0.011). Comparable sensitivity and specificity to those reported in earlier research employing CPUS for identification the cause of ARF in ICU were observed.[9,17] By 82% of instances the original diagnosis based on the clinical of ARF (formed before CPUS) was revised or added to the diagnosis after the combined LUS and TTE results were presented to the treating intensivists.

Table 6. Evaluation of the primary diagnosis in relation to chest ultrasound, echocardiography, and combination CPUS for the chest, cardiac, and combined causes of RF, respectively.

Causes			Diagnosis of lung causes by chest ultrasound		Total	McNemar Test	Measure of Agreement Kappa
			yes	no			
Primary chest causes diagnosis	yes	Count	16	3	19	0.00	16%
		% within Primary diagnosis	84.2%	15.8%	100.0%		
		% within investigational method	44.4%	21.4%	38.0%		
	no	Count	20	11	31		
		% within Primary diagnosis	64.5%	35.5%	100.0%		
		% within investigational method	55.6%	78.6%	62.0%		
	cardiac	causes					
diagnosed	by echocardiography						
	yes	no					
Primary cardiac causes diagnosis	yes	Count	1	0	1	0.00	1%
		% within Primary diagnosis	100.0%	0.0%	100.0%		
		% within investigational method	2.6%	0.0%	2.0%		
	no	Count	37	12	49		
		% within Primary diagnosis	75.5%	24.5%	100.0%		
		% within investigational method	97.4%	100.0%	98.0%		
			Combined lung and heart causes diagnosed by CPUS				
			yes	no			
Primary cardiac and chest causes diagnosis	yes	Count	8	12	20	0.02	12%
		% within Primary diagnosis	40.0%	60.0%	100.0%		
		% within investigational method	33.3%	46.2%	40.0%		
	no	Count	16	14	30		
		% within Primary diagnosis	53.3%	46.7%	100.0%		
		% within investigational method	66.7%	53.8%	60.0%		

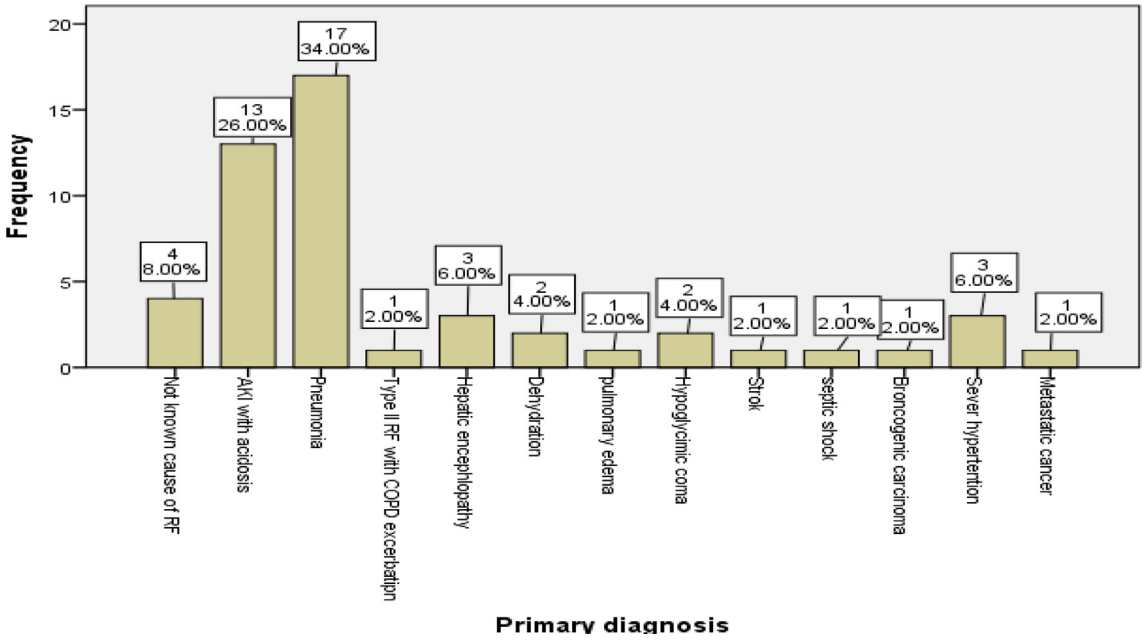

Fig. 1. Primary diagnosis of RF causes in the study group.

Zieleskiewicz et al.[18] performed a prospective multicentric study in 142 intensive care units (ICUs) in France, Belgium, and Switzerland to examine the diagnostic and therapeutic effects of POCUS performed over a 24-h period. They discovered that POCUS was connected to interventions like treatment, imaging orders, and patient triage in 69% of cases, confirmed a suspected diagnosis in 63% of cases, and resulted in a change in diagnosis in 21% of cases. Furthermore, Bapi Barman et al.[19] investigated the application of POCUS in patients receiving intensive care. Of the 108 ARF patients included in this investigation, the etiological diagnosis was altered or modified in 40 (37%) of them, including 18 (17%) "diagnosis changed" cases and 56 (63% "diagnosis modified" cases.

Added' in 22 cases, or 20% Although LUS and TTE have been previously studied in patients who came to the ER or general ICUs with respiratory symptoms, to the best of our knowledge, they have never been investigated in the context of the medical ICU (MICU). Patients in the medical intensive care unit (MICU) come in with a wide variety of respiratory conditions, both primary and secondary. Respiratory failure, the necessity for mechanical ventilation, severe sickness, malfunction of numerous systems, and the presence of multiple coexisting comorbidities are all hallmarks of this group.[19]

There are a number of caveats to this research. To begin, this was an observational research done at a single site on patients at a tertiary MICU. Second, our analysis and subsequent double-investigator confirmation are constrained by the small number of patients available due to the widespread spread of COVID-19. Finally, from another perspective, the patients' diverse genetic makeup may be seen as an asset. The benefits of our research outweigh these flaws. The results of our research demonstrate that incorporating a combined US strategy into clinical assessment not only increases diagnostic accuracy but also modifies the initial diagnosis. Treatment strategy in a significant number of ARF cases, as well as evaluation in distinct patient populations. The majority of patients provided interpretable images, demonstrating the viability of the investigation.

4.1. Conclusion

This research shows that a change in clinical diagnosis and/or therapy is common when using a combined LUS AND TTE as the primary diagnostic test in ARFWe come to the conclusion that routinely screening for ARF upon ICU admission is possible and has a significant diagnostic impact.

Authorship

All authors have a substantial contribution to the article.

Conflict of interest

The authors declared that there were no conflicts of Interest.

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