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Original article

Transthoracic echocardiography as a friend to pulmonologist in respiratory intensive care

Atef Wahdan Elrifai[a], Sayed kinawy[b], Naggeh Mohammed Mahmoud[c], Muhammad Reihan[d].

[a] *Chest disease Department; Al-Azhar Faculty of Medicine (Damietta), Egypt.*
[b] *Chest Disease Department, Faculty of Medicine, Aswan University, Egypt.*
[c] *Cardiology Department, Faculty of Medicine, Aswan University, Egypt*.
[d] *Cardiology Department, Al-Azhar Faculty of Medicine (Damietta), Egypt.*

Corresponding author
Atef Wahdan Elrifai

Chest disease Department;

Al-Azhar Faculty of Medicine (Damietta), Egypt.

ORCID: 0000-0003-4953-4997

Email: atefchest@domazhermedicine.edu.eg

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Background: Bedside echochocardiography is a useful tool in critical care setting. Several studies support the performance of echocardiography by non-cardiologist.

Aim of the work: To evaluate if bedside transthoracic echocardiography (done by intensivist) is useful to provide diagnosis of cardiovascular pathologies of patients with acute respiratory failure in respiratory intensive care, and to assess the interobserver variability between measurements done by intensivist and expert echocardiographer.

Methods: Sixty patients with acute respiratory failure admitted to respiratory critical care unit were evaluated by echocardiography by an intensivist and expert echocardiographer. Interobserver agreement for both readings was done.

Results: there was strong agreement between the reading of both the intensivist and echocardiographer. In addition, significant abnormalities were present especially diastolic dysfunction.

Conclusions: The intensivist detected most abnormalities detected by the expert echocardiographer. The bedside echocardiography is a useful instrument in respiratory critical care unit.

Keywords: Echocardiography; Echocardiographer; intensivist; Respiratory; Critical care.

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Introduction

Bedside use of Doppler echocardiography is a promising, invaluable clinically useful instrument to manage critically ill patients. It provides rapid, comprehensive data about the cardiovascular system[1, 2].

Training intensivists on echocardiography still represent a challenge. In addition, imaging in intensive care facility faced many challenges such as sub-optimal lightening, proper patient positioning, and patient weight gain (due to edema or surgical emphysema), chest drains, dressings for chest/abdomen, ventilation (positive pressure), and rapid change in hemodynamic support and ventilation settings[3]. Integrating echocardiography in clinical setting in ICU may decrease the time to provide optimal treatment when compared with traditional referral to a third party to carry out echocardiography [4].

Echocardiography can rapidly offer a precise and dynamic real-time data on cardiac muscle and its function[5,6] and offers more information than any other traditional cardiac bedside monitor[7, 8]. Over last years, the use of bedside echocardiography as a diagnostic instrument for management optimization of critically ill patients has been well documented[9,10] and a positive therapeutic impact was demonstrated in 24–46% of critical care patients[11, 12]. It is progressively known that intensivists should be skilled in critical care echocardiography[5,6]. The usage of echocardiography in a complementary manner has been proposed to share significantly to improve the diagnosis precision in acute respiratory failure (ARF)[13]. Silva et al. investigated the clinical importance of cardiothoracic ultrasonography in ARF and reported a marked improvement in preliminary precision of diagnosis when compared with ordinary method comprising imaging, clinical and biological information [14].

Aim of the study

To evaluate if bedside transthoracic echocardiography done by intensivist will be a useful tool to provide diagnosis of cardiovascular pathologies of patients with acute respiratory failure admitted to intensive care unit and to assess the interobserver variability between measurements done by intensivist and expert echocardiographer.

Patients and Methods

This study is a prospective study, included patients with ARF, who were admitted to RICU of Aswan university hospital and Al-Azhar Damietta University hospital between April and December 2017. Patients aged 18 years or more, with findings of acute respiratory failure criteria (respiratory rate 25 cycles/min or higher, arterial oxygen tension (PaO_2) <60 mmHg, O_2 saturation < 90% on room air, and arterial carbon dioxide tension ($PaCO_2$)>45 mm Hg with arterial pH< 7.35) were included in the study. This study was done according to the values drawn in the Declaration of Helsinki. Every participant or their families gave informed written consent before enrolment into the study. All information that could potentially lead to their identification were removed.

Study plan

Clinical examination: For each participant, typical health care[15] carried out by the RICU specialist, and these data were recorded: history, examination, blood gases on room air, standard electrocardiography (ECG), chest x-ray, and routine blood analysis. ICU specialists were blinded to the echocardiographic findings.

Echocardiography: all patients underwent echo-cardiography by one investigator who did not share in patient treatment and by expert echocardiographer. Transthoracic echocardiography was performed with PHILIPS ultrasound machine (ClearVue 350) (Amsterdam) and 2- to 4-MHz probe. All participants were investigated in the semi-recumbent position. Echocardiographic evaluation compromised data prescribed elsewhere [16-18], such as systolic function of left ventricle[16], estimation of end-diastolic pressure of left ventricle, and assessment of right ventricular function[17,18], and evaluation of pericardium[18].

Final Diagnosis of ARF: it was carried out by two experts working independently. Each of them review all collected data (clinical presentation, emergency lab results, chest radiography, CT (done for 55%)[19]; and transthoracic Doppler echocardiography carried out by two experts (a cardiologist and intensivist) in an independent manner. The final encountered diagnoses were pulmonary edema (cardiogenic), community acquired pneumonia; acute exacerbation of COPD; embolism and pneumothorax. Patients with multiple diagnoses were excluded. Validated criteria were used and therapeutic response was analyzed.

Statistical Analysis: All Variables in the Excel tables were exported to SPSS software version 17.0 for Windows (IBM, Armonk, NY). Normal distribution was checked by the Kolmogorov-Smirnov test. Continuous data are expressed as mean ± SD (standard deviation) or median (interquartile range). Qualitative data were presented as frequency and percentages. Two means were compared with Student t test or Mann-Whitney U test. The level of agreement among observers for the echocardiographic findings was evaluated using Intraclass Correlation Coefficient (ICC) with 95% confidence intervals (95%CI). Agreement levels were classified as poor (<0.20), fair (0.21-0.40), moderate (0.41-0.60), good (0.61-0.80) and excellent (>0.80)[20]. $p<0.05$ was required to reject the null hypothesis.

Results

A total of 60 consecutive patients were admitted to RICU with ARF, 50.0% male, and 50.0% female, with a mean age of 57.83 [Mean±SD (min-max) 57.8± 14.9 (23.0-83.0)], 18 of them were smokers (30%). Shortness of breath was reported in all subjects, while chest wheeze reported in 23.33% and chest pain in 13.3%. The final diagnosis was chronic obstructive pulmonary disease in 40.0%, lung mass in 3.3%, bronchial asthma in 20%, interstitial lung disease in 10% and pulmonary embolism in 3.3% and pneumonia in 23.33%. No comorbidity was reported in 23.3%, while hypertension was reported in 50.0%, diabetes in 13.3%, ischemic heart disease in 10.0%, renal impairment in 3.3% and hormonal therapy in 3.3%

There was good to excellent agreement between intensivist and echocardiographer in all measurements (table 1).

As regard to segmental wall motion abnormality (SWMA), nearly half of the studied group have SWMA. There was no difference between intensivist and echocardiographer in detecting SWMA with good agreement in the readings (table 2).

Most of cases have diastolic dysfunction which was statistically significant and there was excellent agreement between pulmonologist and echocardiographer in detecting diastolic dysfunction (Table 3).

Aortic valve sclerosis was significant in half cases with excellent agreement between operators. Mitral valve abnormalities were significant in most cases with excellent agreement between operators. Data obtained from tricuspid valve and excellent agreement between intensivist and echocardiographer. 26% of cases had mild pericardial effusion with excellent agreement between operators (Table 4).

After echocardiography 19% of patients received diuretics and 12% received anti-ischemic medications.

Table (1): The echocardiographic examination data in study group

Item	intensivist	Expert echocardiographer	CCI	95%CI
1-EF	55.40±10.56	57.00±10.80	0.955	
2-AO	4.07±1.004	4.04±0.97	0.894	0.828-0.958
3-LA	4.06±0.87	4.16±0.79	0.932	
4- AV	1.55±0.55	1.55±0.50	0.923	0.837-0.973
5-RV	36.68±9.74	38.00±8.11	0.831	
6-SPAP	39.12±11.06	39.92±11.55	0.909	0.856-0.967

EF: ejection fraction, AO: Aortic area dimension, LA: Left atrial, AV: Aortic valve flow m/s, RV: right ventricle, SPAP: systolic pulmonary artery pressure.

Table (2): SWMA (Segmental wall motion abnormalities) examination data in study group

Item	intensivist	Expert	CCI	95%CI
SWMA:				
• No	32(53.3%)	32(53.3%)		
• IDCM	8(13.3%)	8(13.3%)	0.712	0.394-0.863
• LVH	12(20.0%)	12(20.0%)		
• IHD, RWMA	8(13.3%)	8(13.3%)		

IDCM: Ischemic dilated cardiomyopathy, LVH: Left ventricular hypertrophy, IHD: Ischemic heart disease, RWMA: Regional wall motion abnormalities.

Table (3): Diastolic function (DD) data in study group

Item	intensivist	Expert	p-value	CCI	95%CI
Diastolic function:					
• IDD	28(46.67%)	34(56.67%)			
• IIDD	4(6.7%)	4(6.7%)	<0.0001**	0.874	0.835-0.922
• IIIDD	6(10.0%)	4(6.7%)			
• Normal	22(13.3%)	18(30.0%)			

IDD: Type I DD, IIDD: Type II DD, III DD: Type III DD

Table (4): results of cardiac valves and pericardium examination in study group

Valve		Intensivist	Expert	P value	CCI	95% CI
Aortic valve	Normal	30(50.0%)	32(53.3%)	<0.001**	0.826	0.813-0.953
	Mild sclerosis	30(50.0%)	28(46.7%)			
Mitral valve	Normal	22(36.7%)	22(36.7%)			
	RHD	2(3.3%)	4(6.7%)			
	Moderate MR	18(30.0%)	16(26.7%)	<0.001**	0.801	0.799-0.905
	Mild MR	14(23.3%)	14(23.3%)			
	PMVP	2(3.3%)	2(3.3%)			
	AMVP	4(6.7%)	2(3.3%)			
Tricuspid valve	Normal	8(13.3%)	8(13.3%)			
	IDCM	0(0.0%)	0(0.0%)			
	LVH	24(40.0%)	24(40.0%)	<0.001**	0.800	0.793-0.975
	IHD, RWMA	20(33.3%)	18(30.0%)			
	RWMA	8(13.3%)	10(16.7%)			
Pericardium	Normal	44(73.3%)	44(73.3%)	<0.001**	0.974	0.884-0.953
	Mild PE	16(26.7%)	16(26.7%)			

RHD: Rheumatic heart disease, MR: mitral regurgitation, PMVP: Posterior mitral valve prolapses, AMVP: anterior mitral valve prolapse; IDCM: Ischemic dilated cardiomyopathy, LVH: Left ventricular hypertrophy, IHD: Ischemic heart disease, RWMA: Regional wall motion abnormalities. PE: pericardial effusion

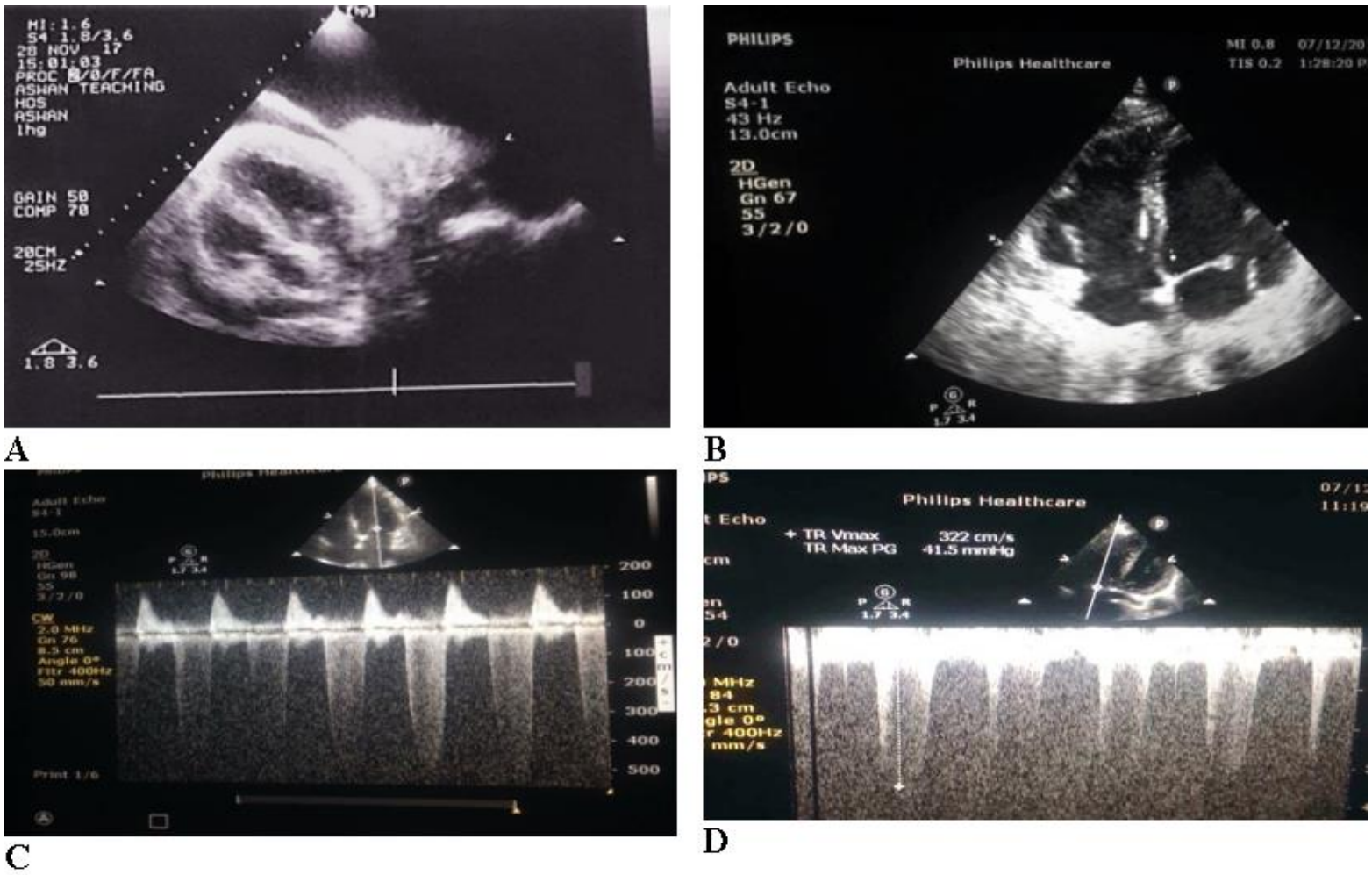

Figure (1): Examples of two-dimensional still-frames obtained from hand-held echocardiographic studies of four distinct patients. (A) Subcostal view obtained from a patient with SOB showed pericardial effusion. (B) Apical four chamber view obtained from a patient with SOB showed dilated right side and discover pulmonary hypertension (C) Apical four chamber view with CWD (continuous wave Doppler) obtained from a patient with SOB showed moderate to severe mitral regurgitation (D) Apical four chamber view with CWD (continuous wave Doppler) obtained from a patient with SOB shows moderate to severe tricuspid regurgitation with estimated PAP (pulmonary artery pressure) 51mmHg.

Discussion

Formal echocardiography in ICU needs 24-h availability of an expert echocardiographer, who could not be easily available in different medical settings. In addition, the echocardiographic examination needs about 1 hour to be carried out, and extra-time was needed for complicated cases[21]. Thus, a goal-directed policy for echocardiography to reach patient with hemodynamic instability, specified to the non-cardiologist intensivists is recently introduced in critical care units [22]. Acute respiratory failure is a frequent condition in critical care settings. Cardiovascular pathologies are common cause or association in acute respiratory failure. In this study we evaluated 60 patients presented with acute respiratory failure by transthoracic echocardiography. In ICU patients, transthoracic echocardiography (TTE) is complementary and is routinely used[23]. When compared to a conventional diagnostic workup, critical care echocardiography improves the diagnostic accuracy in patients with ARF[24].

The present work aimed to assess the usefulness of echocardiography at the bedside performed by intensivist and to test the interoperator agreement between intensivist and cardiologist. According to our results, the interobserver agreements with echocardiography went from good to excellent, generally with wide confidence intervals. Spencer et al.[25] reported that echocardiography is complementary to clinical examination and their results supported the diagnostic utility of echocardiography done by physicians with prior training in echocardiography.

The results of this study and previous reports[24-29]; indicate that trained non-cardiologist can perform echocardiography in critical care setting after receiving training course and can obtain correct results in comparison with expert echocardiographer. In the current study, excellent agreement between intensivist and echocardio-grapher in measurement of EF, the same results obtained by Hugo et al.[22]; they reported a significant correlation between the measurable EF values done by the students and the echocardiographers in the three stages of training.

In the current work, the intensivist detected significant alterations in left ventricle function as the cardiologist. There was significant diastolic dysfunction in the studied population, LV diastolic dysfunction is a risk factor for development of CPE[33]. Pershad et al.[29] reported small variations in the shortening fraction of the LV measures in pediatrics (4.4%) after a brief course of training. In

the same context, Melamed et al.[26] described that intensivists were talented to differentiate normal from abnormal LV function in 86% of their adult populations. In addition, Vignon et al. proved a right assessment of the LV function in 92% of the patients [23], and Kuhl et al. showed precise measurements in 84% of the patients [27].

Spurney et al. assessed the concordance of subjective LV function performed by pulmonologist and cardiologists in pediatric patients and demonstrated a strong correlation (96%)[28]. Longjohn et al. also confirmed a respectable interobserver agreement (κ = 0.87) between pulmonologist and echocardiographers in individually differentiating normal from reduced LV function [19].

The majority of cases in this study had diastolic dysfunction (70%); most of them it is mild diastolic dysfunction (type 1 diastolic dysfunction) (56.6%), the intensivist detected most of them with slight difference but good agreement. Left diastolic dysfunction can be asymptomatic or connected to classical heart failure symptoms (diastolic heart failure). Hypertension and cardiac ischemia, obesity, and diabetes mellitus are risk factors for diastolic heart failure[30].

Also previous reports found high prevalence of ischemic heart disease in COPD patients[31]. To be noted, systemic arterial hypertensions was reported in 50% of patients in the present work, 30% were smokers, whereas 3.3% had received a previous diagnosis of ischemic heart disease and 40% had the diagnosis of COPD.

In this study the intensivist detected all cases of pericardial effusion detected by the cardiologist (Table 8) with excellent agreement (0.974). The same results obtained by Mandavia et al.[32] who showed that non-cardiologists, taught with 1 hour of instruction and 4 hours of practical training, were able to perform echocardiography and interpret it correctly, to assess pericardial effusion, compared with standard echocardiography performed by an expert.

Cardiogenic pulmonary edema (CPE) is a frequent cause of ARF. CPE is progressively ascribed to heart failure with a preserved EF[14]. Since CPE grows due to pulmonary congestion, its diagnosis depends on the recognition of elevated LV filling pressures, irrespective of systolic function. Therefore, patients with LV diastolic dysfunction are at risk of CPE [33]. CCE is ideally suited to identify a causative cardiomyopathy [23]. In this study we found cases with IHD, RWMA and 19 cases with diastolic dysfunction. These finding were of value in aiding the clinical decision to add diuretics or anti-ischemic treatment.

The results of this study showed that clinical decision was improved following echocardiography; in some cases diuretics or anti-ischemic drugs were added depending on echocardiography data[9]. The echocardiography use in a district general hospital ICU in the United Kingdom (UK) lead to a clinical treatment modification in 51% of patients[25]. Echocardiography is considered as an add-on to the clinical examination and is an appreciated tool in ICU for improving outcome [34]. A positive therapeutic impact after echocardiography in 24–46% of critical care patients has been reported in several studies [11,12].

The present study and previous studies demonstrate that the use of echocardiography is useful as a diagnostic tool in critically ill patients and the intensivist is able to carry out bedside echocardiographic examination in critically ill patient and whenever uncertainty occurs regarding the existence of anatomical or functional aberrations, the case should always be discussed with and reevaluated by an echocardiographer [35].

In conclusion, the results of this study reveal that echocardiography can be done at bedside by intensivist after adequate training with accurate results. Echocardiography added to clinical management of cases. The present study recommends incorporating bedside echocardiography into intensivist training programs in Egypt.

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