# The utility of integrating basic echocardiography in routine respiratory intensive care practice

Magdy M. Khalil[a], Ghada S. El-Shahid[b], Iman H.E. Galal[a], Ashraf A. El-Maraghy[a], Hanan H.I. Mahmoud[c]

**Objective** The aim of this study was to evaluate the impact of integrating basic echocardiography in routine assessment of patients admitted to the respiratory intensive care unit and to assess its effect on the outcome of those patients.

**Patients and methods** This prospective cross-sectional study was performed upon 300 patients admitted to the respiratory intensive care unit between January 2015 and December 2015 at Abbasia Chest Hospital. Baseline bedside scanning of patients on admission by portable echo machine for basic echocardiography was reviewed by an experienced cardiologist in all cases as gold standard. Basic echocardiography was done to assess the pericardium, left and right ventricular size and function, valvular lesions, and inferior vena cava. Limited compression ultrasonography was done to detect lower limb deep venous thrombosis (DVT).

**Results** Basic echocardiography showed that 91/300 (30.3%) patients had normal echocardiogram, whereas 209/300 (69.7%) patients had cardiac abnormalities. Basic echocardiography added unsuspected serious conditions to the diagnosis in 33 (11%) patients; five patients with massive pericardial effusion, 22 patients who required inotropics due to dilated cardiomyopathy in 11 patients and ischemic cardiomyopathy in 11 patients, five patients with DVT, and one patient with aortic aneurysm. In addition to this, basic echocardiography confirmed suspected massive pulmonary embolism in seven patients and DVT in 13 patients. Basic echo was able to read the whole finding data as compared to standard echo, with mean sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of 93, 97, 97, 98, and 98%, respectively, except for probable incompetent and probable normal tricuspid valve; the standard echo had the upper hand ($P<0.0001$).

**Conclusion** Basic echocardiography in critically ill patients can readily provide adequate information to get a successful diagnosis and management, especially in life-threatening conditions that can be missed at the primary assessment.
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**Keywords:** basic, echo, intensive care unit, respiratory

Department of, [a]Chest Diseases, [b]Cardiac Diseases, Faculty of Medicine, Ain Shams University, Cairo, [c]Department of Pulmonology, Zagazig Chest Hospital, Zagazig, Egypt

Correspondence to Hanan H.I. Mahmoud, Department of Pulmonology, Zagazig Chest Hospital , Zagazig, 44511, Egypt.
e-mail: hanan.hosny38@yahoo.com

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## Introduction

In a critically ill patient, the diagnostic methods must be rapid, reliable, and reproducible to confirm a successful therapeutic strategy, as the patient is under an intense threat for his life [1].

Cardiac abnormalities are common in critically ill patients and may be unsuspected on clinical examination, despite their hemodynamic significance [2].

Cardiac ultrasound is considered one of the best diagnostic methods available at the ICU, as it can be performed at the bedside and can provide real time information in a noninvasive form for making vital decisions such as continuation of fluid therapy, early use of vasoactive or inotropic agents, pericardiocentesis in cardiac tamponade, and thrombolysis in massive pulmonary embolism [1].

Basic echocardiography can be used for the assessment of global and regional left ventricular (LV) systolic function, and right ventricular (RV) impairment [3].

As cardiologists are not always immediately available, goal-directed echocardiography (GDE) has become increasingly used by trained intensivists in the ICUs [4].

The aim of the current study was to evaluate the impact of integrating basic echocardiography in routine assessment of patients admitted to the respiratory intensive care unit (RICU) and to assess its effect on the outcome of those patients.

## Patients and methods

This cross-sectional study was done prospectively on 300 patients admitted to the RICU between January 2015 and December 2015 at Abbasia Chest Hospital, Cairo, Egypt. No specific contraindications existed in the procedure. Informed consent was obtained from all patients or their relatives and the study was approved by the institutional ethical committee. Baseline bedside scanning of patients in the RICU on admission for basic echocardiography was performed by portable echo machine (Siemens SONOLINE G60 S System, USA), using the phased array (2.5 MHz) transducer for better resolution of the heart. Basic echocardiography was performed by a certified pulmonologist and reviewed by an experienced cardiologist in all cases as gold standard. Patients were scanned either in supine or left lateral (as tolerated) position. Transthoracic echo views were obtained and recorded as possible in the parasternal long axis, parasternal short axis, apical four-chamber, apical two-chamber, and subcostal views. The average time needed to complete basic echocardiography scanning was 10–15 min.

Basic echocardiography was done to assess:

(1) The pericardium: for moderate or large pericardial effusion and cardiac tamponade.
(2) LV size and function: visual estimation of global and regional ventricular contractility were assessed.
(3) RV size and function: to detect the presence of pulmonary hypertension, RV hypertrophy, RV dilatation, right atrial dilatation, and RV failure. RV/LV ratio greater than 0.6 was considered as indicating a significant RV overload.
(4) Valvular anatomy and function: crude valvular mobility, valvular incompetence, valvular stenosis (defined as thickened leaflets with restricted mobility), and valve prosthesis were evaluated.
(5) Inferior vena cava (IVC) diameter and collapsibility:
    (a) Sonographic measurment of IVC and conventional venography (i.e. heart rate, blood pressure, central venous pressure), and hemodynamic and intravascular volume status variables were recorded.
    (b) IVC collapsibility was computed based on the minimum and maximum IVC diameters, and determined by M-mode ultrasonography of the vein wall.
    (c) The collapsibility index (also known as the caval index) is defined as: (the maximal diameter–minimal diameter/maximal diameter) (Table 1) [5].

**Table 1 Correlation between inferior vena cava size and central venous pressure during spontaneous respiration**

| Correlation between IVC size and CVP | | |
|---|---|---|
| IVC size (cm) | Respiratory change | CVP (cm $H_2O$) |
| <1.5 | Total collapse | 0–5 |
| 1.5–2.5 | >50% collapse | 6–10 |
| 1.5–2.5 | <50% collapse | 11–15 |
| >2.5 | <50% collapse | 16–20 |
| >2.5 | No change | >20 |

CVP, central venous pressure; IVC, inferior vena cava.

(6) Lower limb scan for deep venous thrombosis (DVT) as necessary:
    (a) By limited compression ultrasonography (LCU) using linear transducer (5.0–13.3 MHz), limited compression evaluation was done for specific areas of the leg, including common femoral vein, deep femoral vein, saphenous vein, superficial femoral vein, and popliteal vein behind the knee.
    (b) The pathognomonic sonographic finding of DVT is the incomplete compression of the anterior and posterior walls of the vein with applied probe pressure [6].

### Statistical analysis

The results were tabulated and statistically analyzed as to how routine cardiac ultrasound would confirm, add, or change a diagnosis, and to what extent it would affect the plan of management and outcome of the patients admitted to the RICU. Concordance between the investigator's and the cardiologist's basic echo findings was evaluated.

The collected data were coded, tabulated, and statistically analyzed using IBM SPSS statistics software version (22.0, statistical package for social sciences, 2013; IBM Corp., Chicago, Illinois, USA).

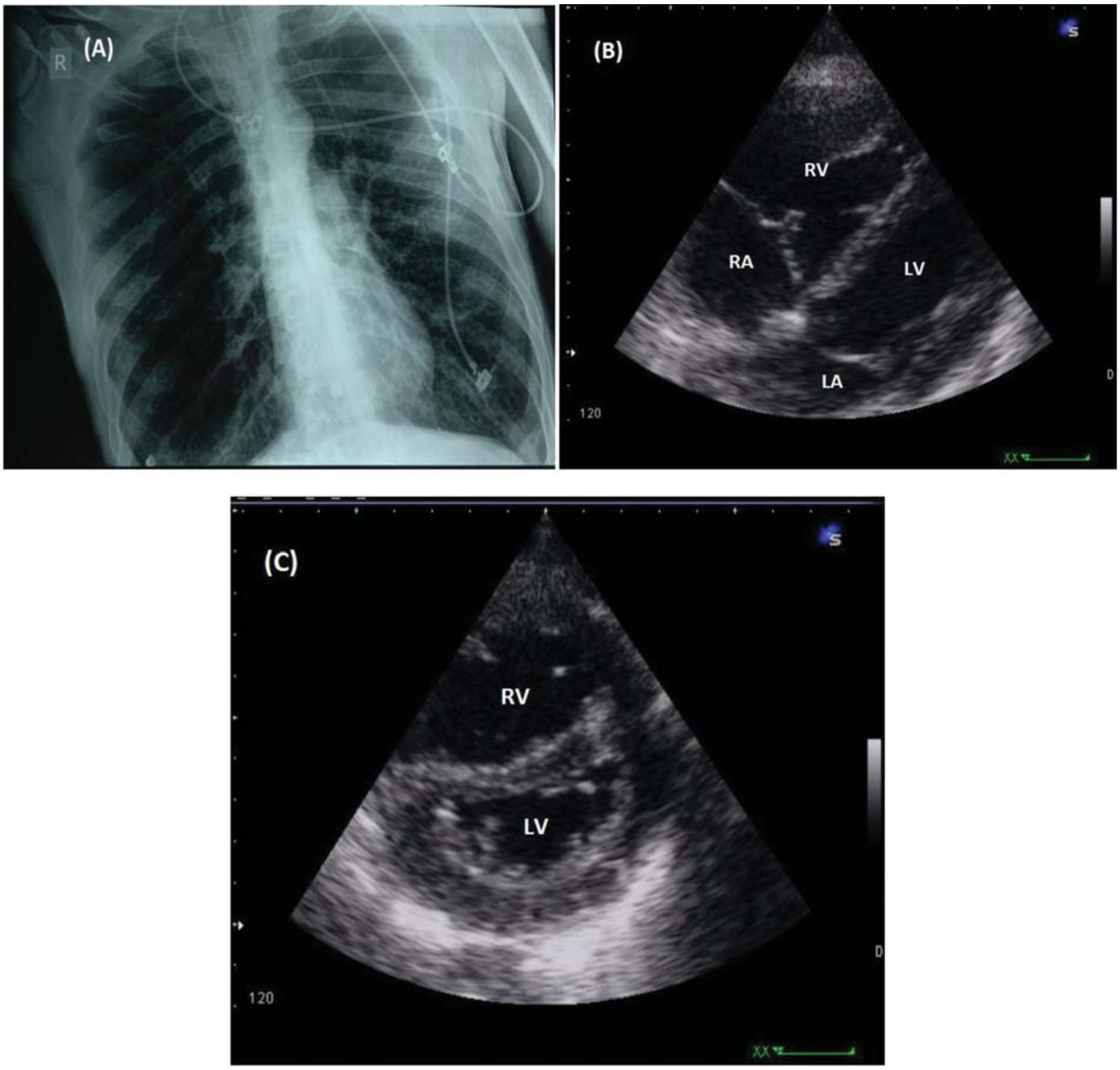
Continuous variables were expressed as the mean±SD, and the categorical variables were expressed as a number (percentage). $\chi^2$-Goodness-of-fit test was used to determine whether the proportion in each category differ from the expected proportion. Differences between the basic and standard echo were determined by analysis of variance test. Sensitivity and specificity were used to evaluate the clinical test. Positive and negative predictive values (PPV and NPV) depend on the prevalence of disease in the population of interest. *P* less than 0.05 is considered statistically significant.

## Results

A total of 385 patients were admitted to the RICU. Eighty-five (22.1%) patients were excluded because of morbid obesity in nine (2.3%) patients, with no echocardiography window for examination, 34 (8.8%) patients died before scanning during the first 24 h of admission, and 42 (10.9%) patients were missed because of unavailability of a sonographer.

A total of 300 patients admitted to the RICU were enrolled, and included 221 males and 79 females, with mean age±SD 52±17.3 years (range: 13–96 years). There were 139/300 (46.3%) patients admitted

**Figure 1**




Echocardiogram in 53-year-old male patient, heavy cig. smoker, and admitted to RICU because of acute infective exacerbation of COPD, with RFII and chest radiography showing hyperinflation with increased bronchovascular markings (a). Basic echocardiography added criteria suggestive of pulmonary hypertension; subcostal view of the heart showed dilated right ventricle (RV) and right atrium (RA) (b) with D-shaped left ventricle (LV) and flattened interventricular septum (c). COPD, chronic obstructive pulmonary disease.

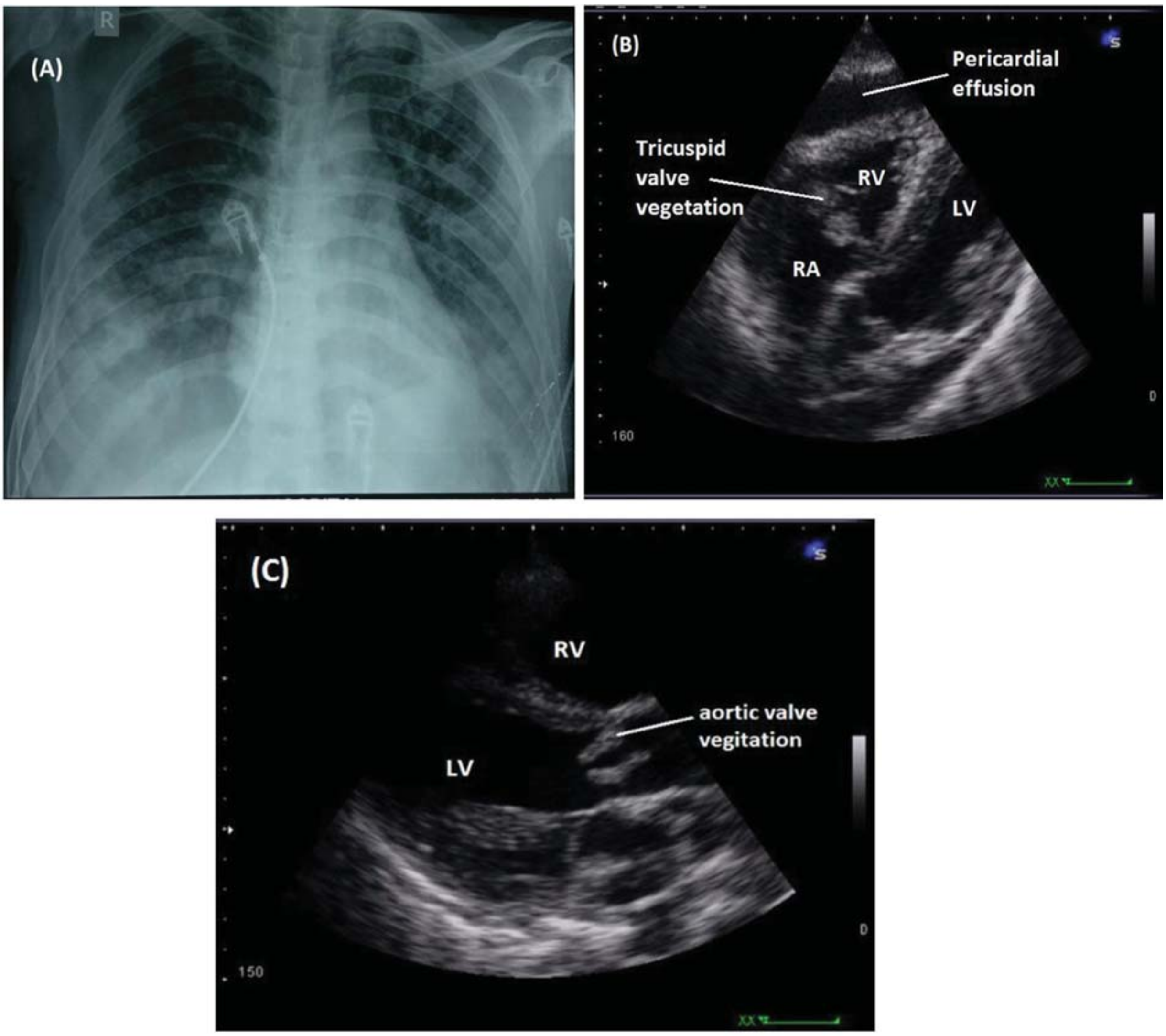
because of respiratory failure type I, 27/300 (9%) patients admitted because of respiratory failure type I and shock, 130/300 (43.3%) patients admitted because of respiratory failure type II, and 4/300 (1.3%) patients admitted because of respiratory failure type II and shock.

The underlying illness among the studied group included chronic obstructive pulmonary disease in 114/300 (38%) patients, pneumonia in 74/300 (24.7%) patients, pulmonary tuberculosis in 47/300 (15.7%) patients, interstitial lung disease in 19/300 (6.3%) patients, pleural effusion in 20/300 (6.7%) patients, pneumothorax in 7/300 (2.3%) patients, lung mass in 12/300 (4%) patients, lung abscess in 14/300 (4.7%) patients, bronchiectasis in 5/300 (1.7%) patients, acute severe asthma in 6/300 (2%) patients, pulmonary edema in 6/300 (2%) patients, pulmonary embolism in 11/300 (3.7%) patients, and obesity hypoventilation syndrome in 5/300 (1.7%) patients (Figs 1–7)..

### Impact of basic echocardiography on diagnosis

Basic echocardiography added unsuspected serious conditions to the diagnosis in 33 (11%) patients; five patients with massive pericardial effusion, 22 patients who required inotropics because of dilated cardiomyopathy in 11 patients and ischemic cardiomyopathy in 11 patients, five patients with DVT, and one patient with aortic aneurysm. It also confirmed seven (2.3%) patients with massive

**Figure 2**




Echocardiogram in 27-year-old male patient, cig. smoker, intravenous drug abuser, and presented by multiple pyemic lung abscesses and bilateral pleural effusion in chest radiography (a). Basic echo revealed large vegitation on tricuspid valve and mild pericardial effusion (b). The patient was transferred to thoracic surgery department for decortication (multiloculated empyema) and re-admitted to RICU after 3 months with septic shock. Follow-up basic echocardiography revealed tricuspid and aortic valve vegitation with mild pericardial effusion (c). LV, left ventricle; RA, right atrium; RICU, respiratory intensive care unit; RV, right ventricle.

pulmonary embolism and 13 (4.3%) patients with DVT (Table 2).

Basic echocardiography changed the dignosis by exclusion of infective endocarditis in 18 (6%) patients, lower limb DVT in 32 (10.7%) patients, ischemic cardiomyopathy in three (1%) patients, massive pulmonary embolism in three (1%) patients, and dilated cardiomyopathy in two (0.7%) patients.

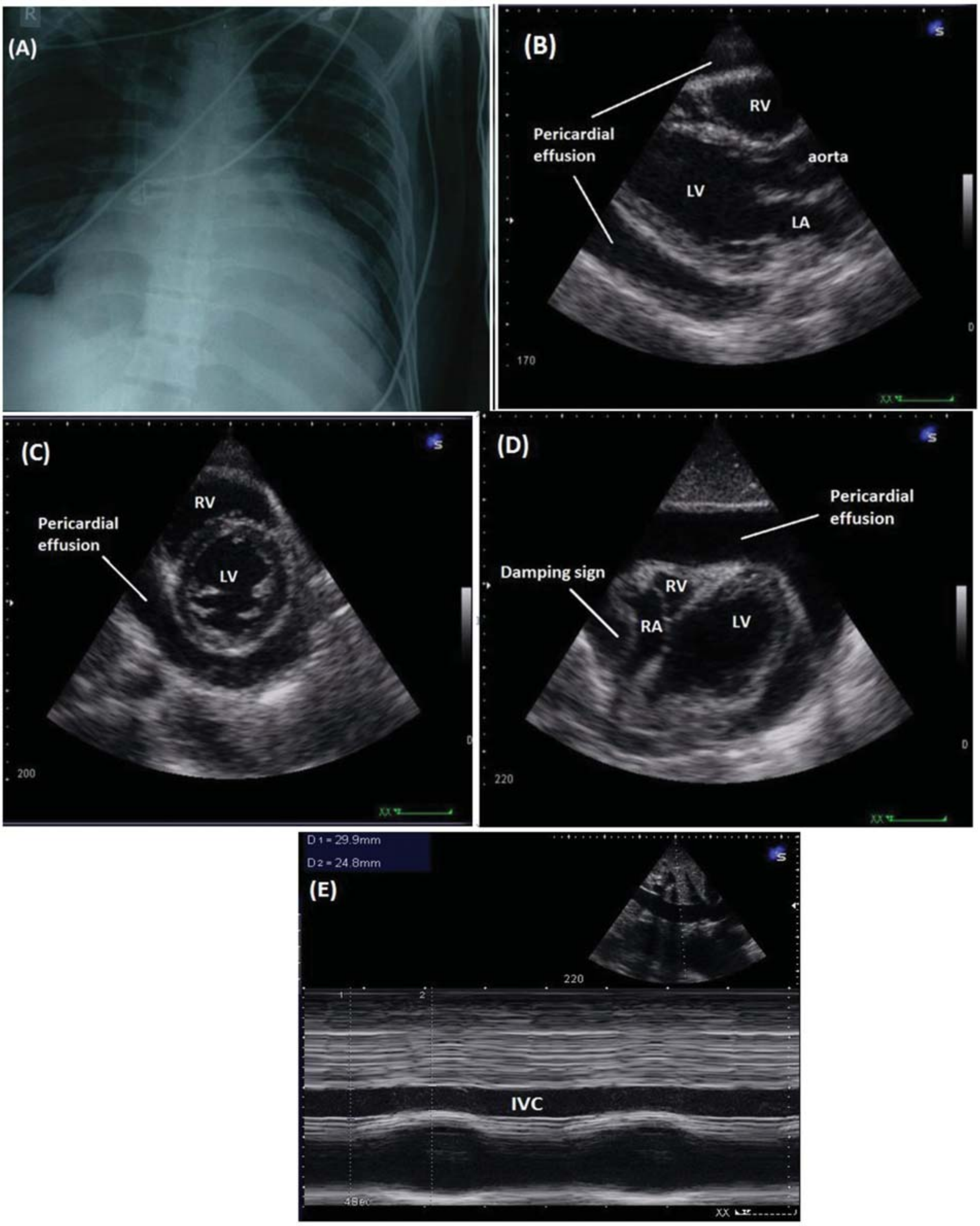
### Impact of basic echocardiography on the plan of management

Basic echocardiography supported the use of anti-ischemic measures in eight (2.7%) patients with ischemic cardiomyopathy and fluid resuscitation in 17 (5.7%) patients. Fluid restriction was supported in six (2%) patients. In addition to this, therapeutic anticoagulant prescription was supported in 16 (5.3%) patients.

Basic echocardiography added to plan of management, medical therapy in the form of therapeutic anticoagulants to eight (2.7%) patients, anti-ischemic measures to 28 (9.3%) patients, inotropics to 22 (7.3%) patients, and diuretics to 27 (9%) patients.

Surgical intervention (valve repair or valve replacement) was recommended in 20 (6.7%) patients with persistent infective endocarditis, and in four (1.3%) patients with tight mitral stenosis. Pericardiocentesis was performed in two (0.7%) patients with cardiac tamponade. Thrombolysis with streptokinase was prescribed in

**Figure 3**

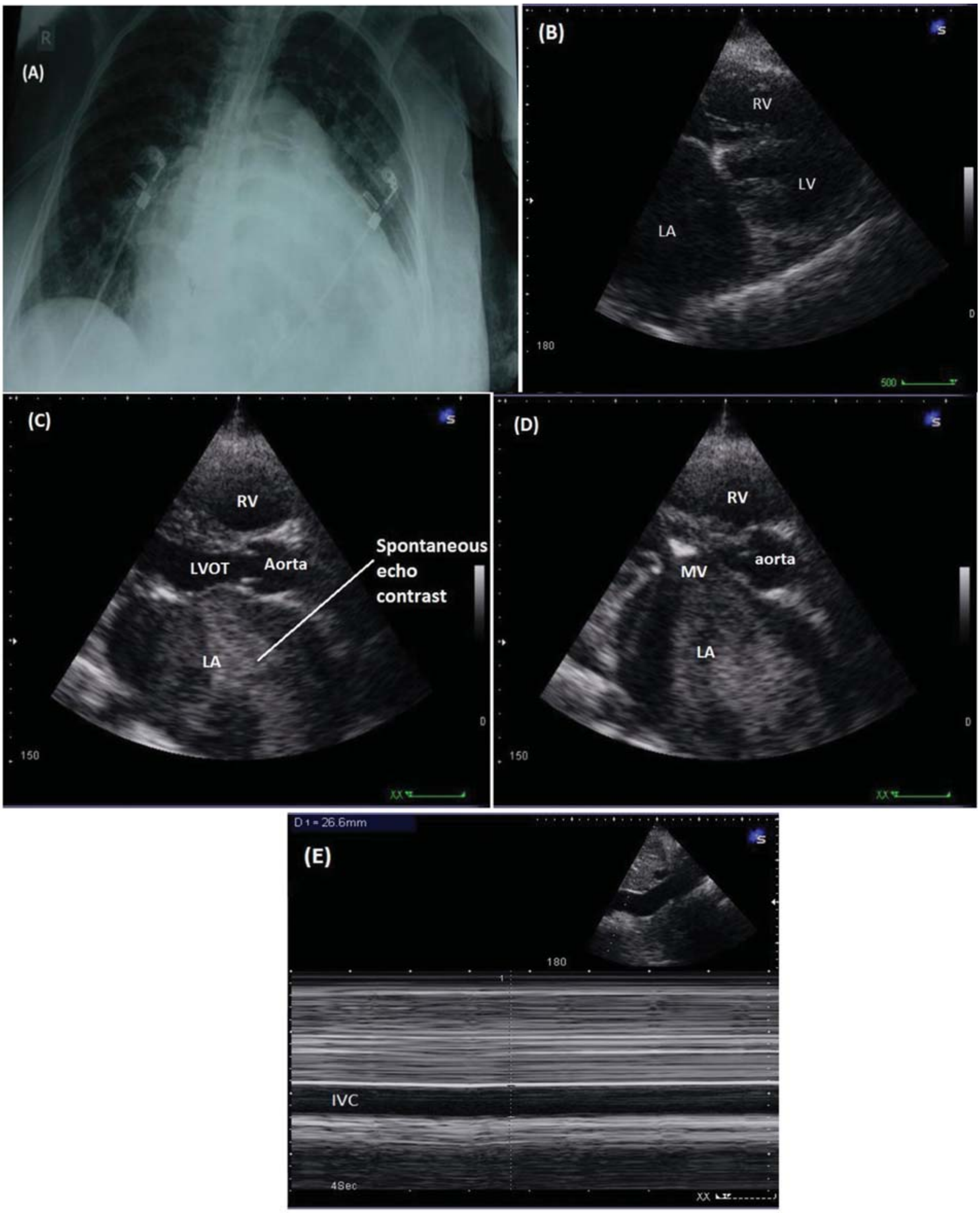



Echocardiogram in 35-year-old male patient, heavy cig. smoker, known COPD, presented by dyspnea and chest wheezes. Chest radiography demonstrates marked enlargement of the cardiac outline (water bottle sign) (a). Basic echocardiography revealed massive pericardial effusion (b, c) with signs of cardiac tamponade (d) and distended IVC (e). COPD, chronic obstructive pulmonary disease; IVC, inferior vena cava; LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle.

seven (2.3%) patients with massive pulmonary embolism. Follow-up of diagnosed pericardial effusion was performed in four (1.3%) patients because of moderate amount and in three (1%) patients with massive pericardial effusion for fear of cardiac tamponade. Follow-up echocardiography was done after pericardiocentesis in two (0.7%) patients.

Basic echocardiography changed the plan of management, where intravenous fluids were

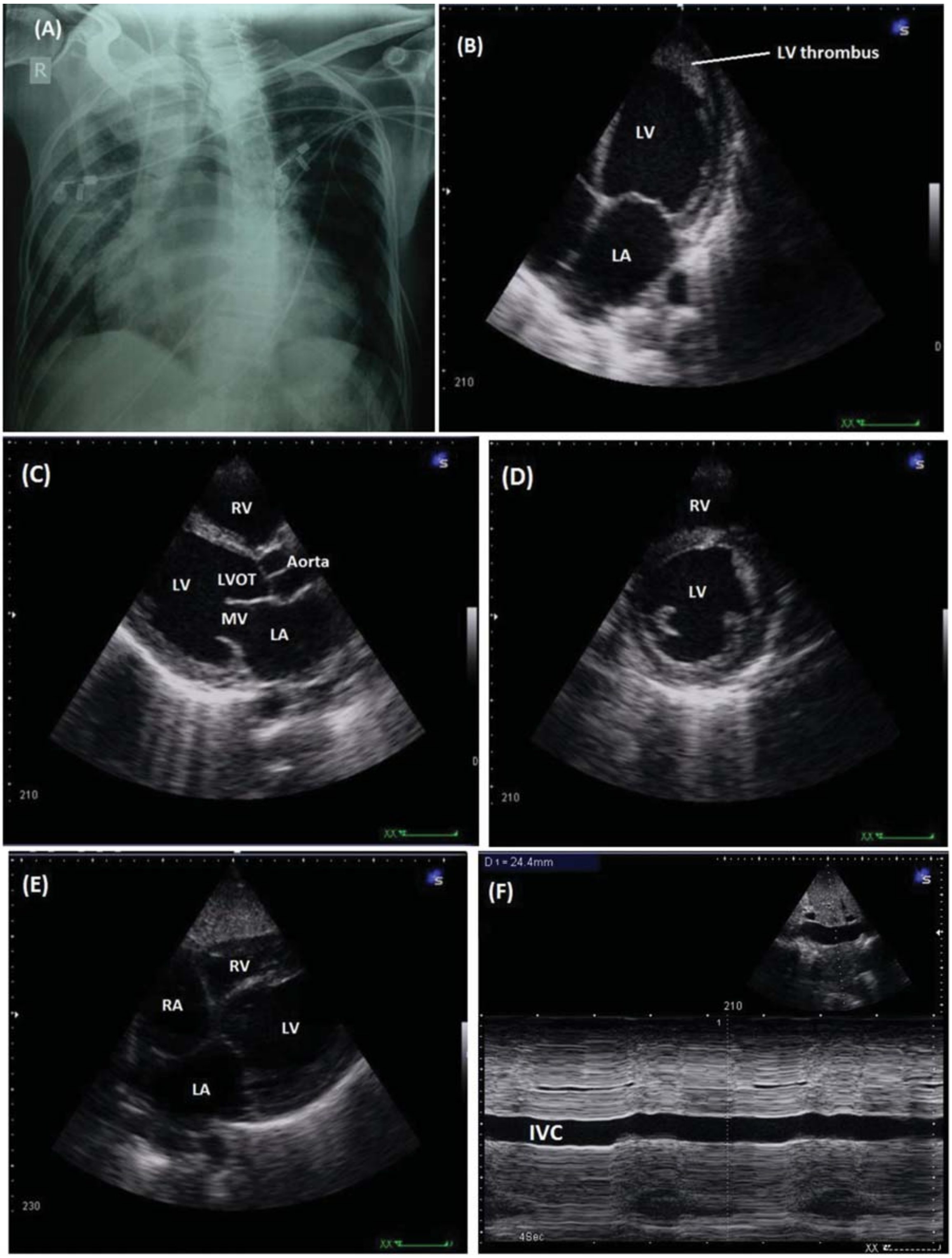
**Figure 4**




Echocardiogram in 54-year-old female patient presented by pulmonary edema. Chest radiography showed cardiomegaly (a). Basic echocardiography showed hugely dilated left atrium with spontaneous echo contrast (echogenic swirling pattern of blood flow caused by blood stasis because of severe mitral stenosis) (b, c), rheumatic calcification of both leaflets of mitral valve with restricted mobility (d). Distended IVC (e). Therapeutic anticoagulant was added because of LA spontaneous echo contrast. IVC, inferior vena cava; LA, left atrium; LV, left ventricle; MV, mitral valve; RV, right ventricle.

discontinued in 19 (6.3%) patients, anticoagulants were discontinued in three (1%) patients, antiarrhythmic drug was discontinued in one case because of detection of right atrial thrombus, and inotropics were discontinued in one patient because of severe aortic stenosis. Antibiotics for infective endocarditis were prescribed in 20 (6.7%) patients.

**Figure 5**

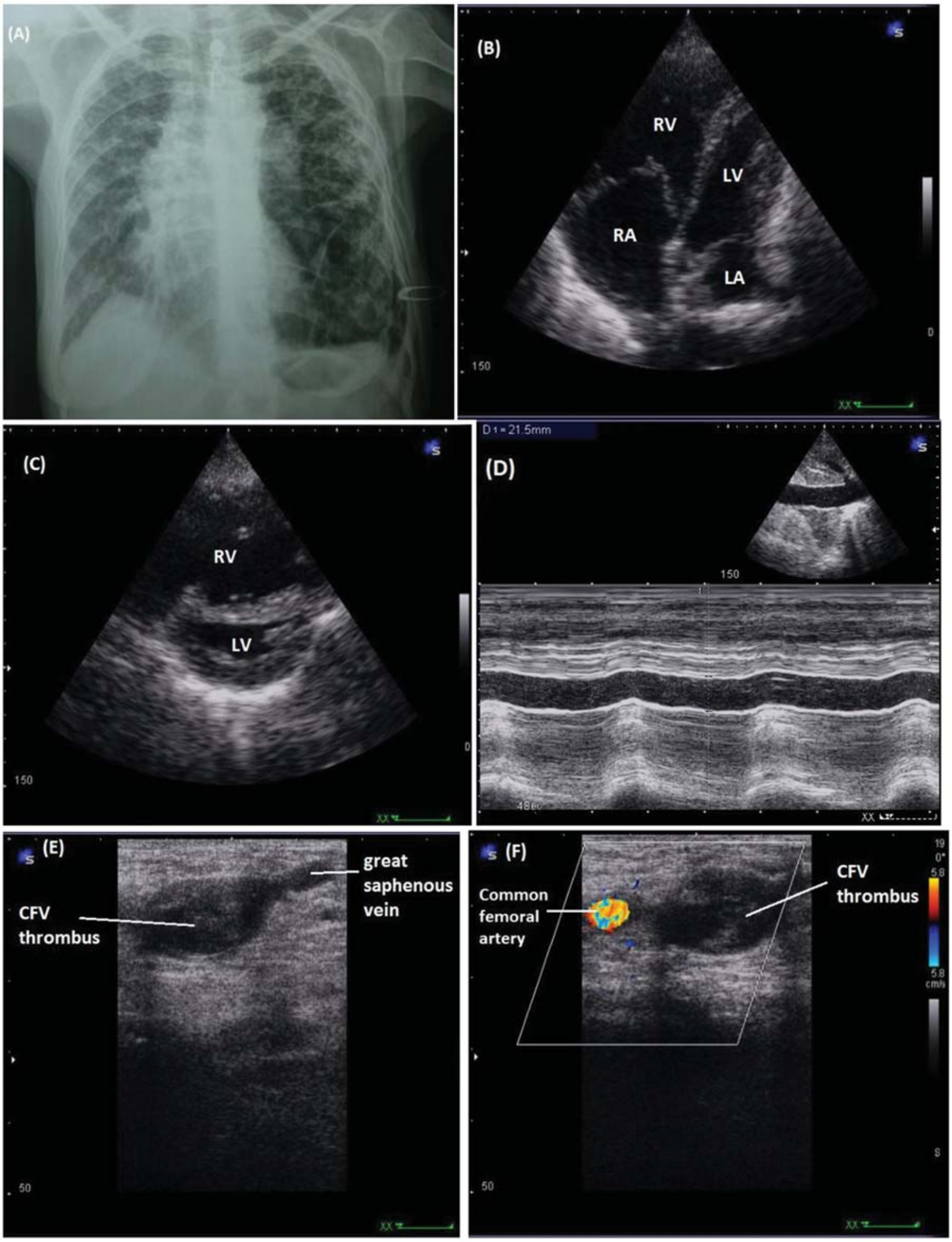



Echocardiogram in 42-year-old male patient, heavy cig. Smoker, and intravenous drug abuser; chest radiography showed right-sided pneumonia (a). Basic echocardiography showed markedly dilated LV with markedly reduced systolic function, large apical LV thrombus, dilated left atrium (b, c, d, e), and distended IVC (f). Inotropic agents, diuretics, and therapeutic anticoagulants (for LV thrombus) were added. IVC, inferior vena cava; LA, left atrium; LV, left ventricle; LVOT, left ventricular outflow tract; MV, mitral valve; RA, right atrium; RV, right ventricle.

### Comparison between basic and standard echocardiographic findings

Comparison between basic echocardiographic findings as done by the investigator (pulmonologist) and standard echocardiographic findings as done by the expert (cardiologist) (Table 3) by using $\chi^2$-goodness-of-fit test showed that there is no significant difference in proportion in each category (basic echo and standered echo) and the expected proportion, except in probable incompetence of tricuspid valve and

**Figure 6**

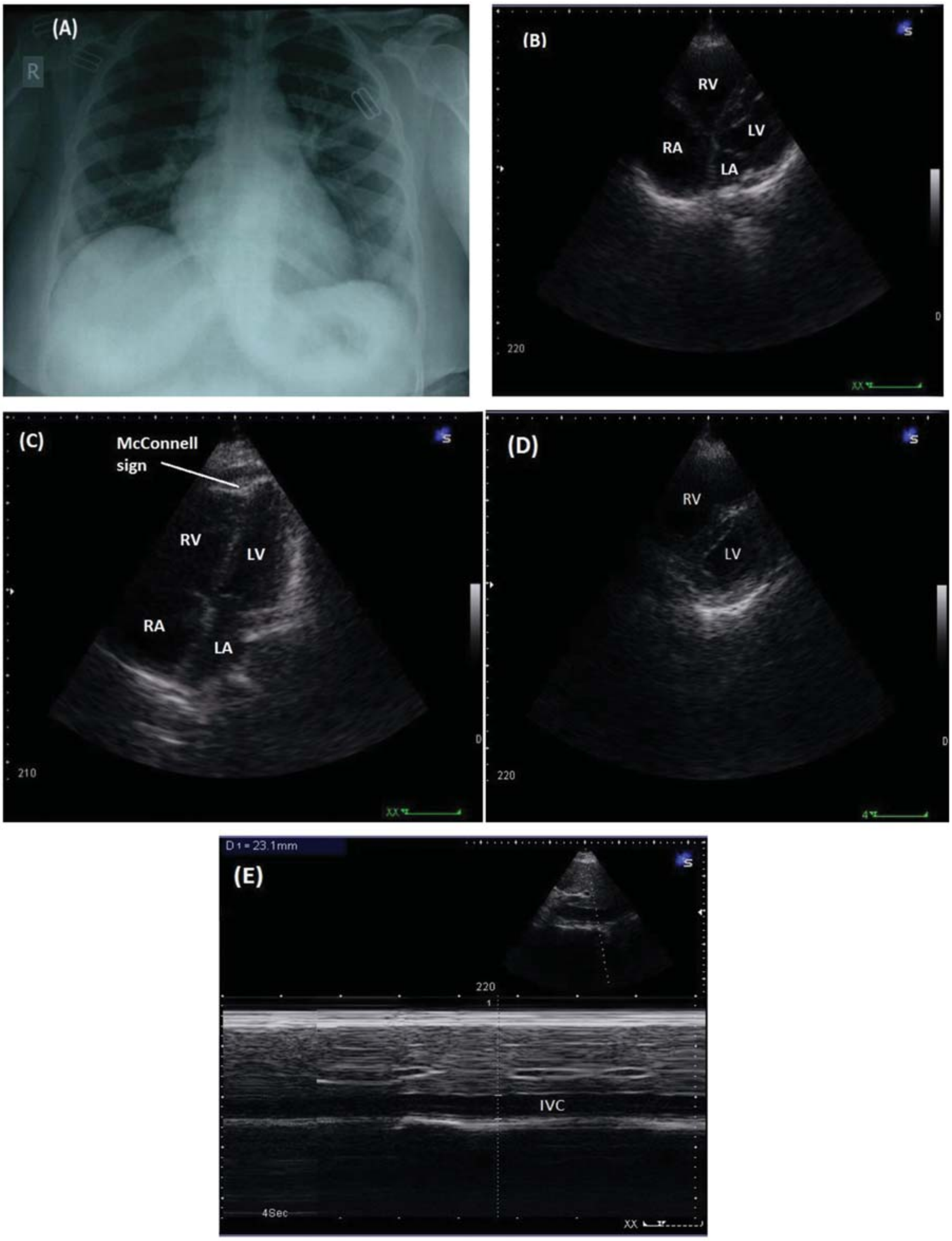



Echocardiogram in 48-year-old female patient diagnosed as idiopathic pulmonary fibrosis (IPF). CXR showed bilateral reticular shadowing (a). Basic echocardiography showed severely dilated RV and RA (b) with diastolic flattening of inter-ventricular septum (IVS) and D-shaped LV (c). Inferior vena cava was distended with no respiratory change in size (d). Color Doppler study of both lower limbs reveal left common femoral vein thrombosis (e, f), hence therapeutic anticoagulant was added. CFV, common femoral vein; CXR, chest radiography; LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle.

probable normal tricuspid valve, $P$ value less than 0.0001. This indicates that the basic echocardiography was able to read the whole-findings data as compared to standard echo, except with (probable incompetence of tricuspid valve and probable normal tricuspid valve); the standard echo had the upper hand.

The basic echo at probable incompetence of tricuspid valve had minimum sensitivity, NPV, and accuracy

Figure 7




Echocardiogram in 32-year-old female patient presented by acute onset of dyspnea, chest pain, and hemoptysis. CXR was normal (a). Basic echo revealed severely dilated RV and RA, with impaired function of RV sparing the apex (McConnell sign) (b, c), flattened interventricular septum with D-shaped LV (d). IVC was distended with no respiratory change in size (e). Color Doppler study of both lower limbs was unremarkable. The patient received thrombolytic therapy on the basis of echo findings. CXR, chest radiography; IVC, inferior vena cava; LA, left atrium; LV, left ventricle; RA, right atrium; RV, right ventricle.

(ACC) level, 30, 63, and 68%, respectively, even with 100% PPV and specificity, whereas at probable normal tricuspid valve, it showed minimum PPV, specificity, and ACC, 63, 30, and 68%, respectively, even with 100% sensitivity and NPV (Table 4).

The mean sensitivity of basic echo in detecting all parameters included in echocardiography was 93% with SD of 14% and ranged from 30 to 100%, and mean specificity of 97% with SD of 12% and ranged from 30–100%.In addition to this, the ability of basic

**Table 2 Impact of basic echocardiography on diagnosis**

| | *n* (%) |
|---|---|
| Basic echocardiography confirmed diagnosis | |
| Normal echocardiogram | 91(30.3) |
| Localized hypokinesia suggestive of ischemic heart disease | 8 (2.7) |
| Global hypokinesia suggestive of dilated cardiomyopathy | 10 (3.3) |
| Criteria suggestive of pulmonary hypertension (*N*=12) | |
| Dilated right ventricle | 12 (100) |
| Dilated right atrium | 12 (100) |
| D-shaped left ventricle | 12(100) |
| Flattened interventricular septum | 12 (100) |
| Criteria suggestive of massive pulmonary embolism (*N*=7) | |
| Dilated right ventricle | 7 (100) |
| Dilated right atrium | 7 (100) |
| D-shaped left ventricle | 7 (100) |
| Paradoxical septal motion | 7 (100) |
| Localized hypokinesia of right ventricle (McConnel sign) | 5 (71.4) |
| Plethoric IVC | 7 (100) |
| Tricuspid valve vegetation suggestive of Infective endocarditis | 20 (6.7) |
| Calcified thickened mitral valve suggestive of rheumatic heart disease | 2 (0.7) |
| Valve prosthesis | 2 (0.7) |
| Normal volume status | 210 (70) |
| Intravascular volume depletion | 17 (5.7) |
| Increased right atrium pressure | 14 (4.7) |
| Lower limb deep venous thrombosis (total *N*=50) | 13 (26) |
| Basic echocardiography added to diagnosis | |
| Localized hypokinesia suggestive of ischemic cardiomyopathy | 28 (9.3) |
| Global hypokinesia suggestive of dilated cardiomyopathy | 35 (11.7) |
| Left ventricular hypertrophy suggestive of hypertensive heart disease | 8 (2.7) |
| Criteria suggestive of pulmonary hypertension (*N*=113) | |
| Dilated right ventricle | 113 (100) |
| Dilated right atrium | 113 (100) |
| D-shaped left ventricle | 36 (31.9) |
| Flattened interventricular septum | 36 (31.9) |
| Pericardial effusion | |
| Mild | 25 (8.3) |
| Moderate | 4 (1.3) |
| Massive | 3 (1) |
| Massive with cardiac tamponade | 2 (0.7) |
| Valvular lesions | |
| Aortic valve vegetation | 2 (0.7) |
| Calcification | 7 (2.3) |
| Mitral valve prolapse | 2 (0.7) |
| Probable stenosis of aortic valve | 4 (1.3) |
| Probable stenosis of mitral valve | 7 (2.3) |
| Probable incompetence of tricuspid valve | 41 (13.7) |
| Probable incompetence of mitral valve | 56 (18.7) |
| Calcified thickened mitral valve with restricted mobility suggestive of rheumatic heart disease | 4 (1.3) |
| Aortic aneurysm | 1 (0.3) |
| Intravascular volume depletion | 2(0.7) |
| Increased right atrium pressure | 43 (14.3) |
| Lower limb deep venous thrombosis | 5 (1.7) |
| Basic echocardiography changed diagnosis | |
| Exclude infective endocarditis | 18 (6) |
| Exclude lower limb DVT | 32 (10.7) |
| Exclude ischemic cardiomyopathy | 3 (1) |
| Exclude massive pulmonary embolism | 3 (1) |
| Exclude dilated cardiomyopathy | 2 (0.7) |

DVT, deep venous thrombosis; IVC, inferior vena cava.

**Table 3 Comparison between basic echocardiographic findings as done by the investigator (pulmonologist) and standard echocardiographic findings as done by the expert (cardiologist)**

| Findings | Basic echo (number of cases) | standard echo (number of cases) | $\chi^2$ | *P* |
|---|---|---|---|---|
| Normal echocardiogram | 91 | 91 | 0 | 1 |
| Left ventricle | | | | |
| Left ventricular contractility | | | | |
| Normal | 217 | 213 | 0.04 | 0.8 |
| Hyperkinetic | 6 | 6 | 0 | 1 |
| Localized hypokinesia | 32 | 36 | 0.2 | 0.6 |
| Global hypokinesia | 45 | 45 | 0 | 1 |
| Left ventricular dilatation | 52 | 56 | 0.1 | 0.7 |
| Left ventricle hypertrophy | 7 | 8 | 0.06 | 0.7 |
| D-shaped left ventricle | 52 | 55 | 0.08 | 0.7 |
| Left ventricular thrombus | 1 | 1 | 0 | 1 |
| Left atrium | | | | |
| Left atrial dilatation | 54 | 58 | 0.1 | 0.7 |
| Right ventricle | | | | |
| Right ventricular contractility | | | | |
| Normal | 283 | 279 | 0.02 | 0.9 |
| Localized hypokinesia | 4 | 5 | 0.1 | 0.7 |
| Global hypokinesia | 13 | 16 | 0.3 | 0.6 |
| Right ventricular dilatation | 129 | 132 | 0.03 | 0.8 |
| Right atrium | | | | |
| Right atrial dilatation | 129 | 132 | 0.03 | 0.8 |
| Right atrial thrombus | 1 | 1 | 0 | 1 |
| Septal dynamics | | | | |
| Normal | 176 | 164 | 0.4 | 0.5 |
| Hypokinetic | 72 | 81 | 0.5 | 0.4 |
| Paradoxical motion | 52 | 55 | 0.8 | 0.7 |
| Valvular lesions | | | | |
| Vegetation | 17 | 20 | 0.2 | 0.6 |
| Calcification | 7 | 7 | 0 | 1 |
| Prolapse | 1 | 2 | 0.3 | 0.5 |
| Valve prosthesis | 2 | 2 | 0 | 1 |
| Probable stenosis of aortic valve | 4 | 3 | 0.1 | 0.7 |
| Probable stenosis of mitral valve | 7 | 6 | 0.1 | 0.7 |
| Probable incompetence of tricuspid valve | 41 | 137 | 51.7 | 0.0001 |
| Probable incompetence of mitral valve | 56 | 71 | 1.7 | 0.2 |
| Probable normal mitral valve | 233 | 218 | 0.5 | 0.5 |
| Probable normal tricuspid valve | 259 | 163 | 21.8 | 0.0001 |
| Pericardial effusion | | | | |
| Mild | 22 | 25 | 0.1 | 0.6 |
| Moderate | 4 | 4 | 0 | 1 |
| Massive | 3 | 3 | 0 | 1 |
| Massive with cardiac tamponade | 2 | 2 | 0 | 1 |
| Aortic aneurysm | 1 | 1 | 0 | 1 |
| Inferior vena cava | | | | |
| Normal volume status | 210 | 210 | 0 | 1 |
| Intravascular volume depletion | 19 | 19 | 0 | 1 |
| Increased right atrial pressure | 57 | 57 | 0 | 1 |
| Not possible to assess inferior vena cava using sonography | 14 | 14 | 0 | 1 |
| Limited compression ultrasonography | | | | |
| Normal | 35 | 32 | 0.1 | 0.7 |
| Deep venous thrombosis | 15 | 18 | 0.2 | 0.6 |

echo for PPV and NPV varied from 63 to 100%. Finally, the accuracy of basic echo ranged from 68 to 100% (Table 5).

## Discussion

Echocardiography has become a crucial tool in the diagnosis of critically ill patients. Echocardiography

**Table 4 Sensitivity, specificity, positive predictive value, negative predictive value, and ACC of different parameters in basic echo reading**

| Total=300 | | | | | | | |
|---|---|---|---|---|---|---|---|
| Findings | Basic echo (number of cases) | standard echo (number of cases) | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) | ACC |
| Normal echocardiogram | 91 | 91 | 100 | 100 | 100 | 100 | 100 |
| Left ventricle | | | | | | | |
| Left ventricular contractility | | | | | | | |
| Normal | 217 | 213 | 100 | 95 | 98 | 100 | 99 |
| Hyperkinetic | 6 | 6 | 100 | 100 | 100 | 100 | 100 |
| Localized hypokinesia | 32 | 36 | 89 | 100 | 100 | 99 | 99 |
| Global hypokinesia | 45 | 45 | 100 | 100 | 100 | 100 | 100 |
| Left ventricular dilatation | 52 | 56 | 93% | 100 | 100 | 98 | 99 |
| Left ventricle hypertrophy | 7 | 8 | 88 | 100 | 100 | 100 | 100 |
| D-shaped left ventricle | 52 | 55 | 95 | 100 | 100 | 99 | 99 |
| Left ventricular thrombus | 1 | 1 | 100 | 100 | 100 | 100 | 100 |
| Left atrium | | | | | | | |
| Left atrial dilatation | 54 | 58 | 93 | 100 | 100 | 98 | 99 |
| Right ventricle | | | | | | | |
| Right ventricular contractility | | | | | | | |
| Normal | 283 | 279 | 100 | 81 | 99 | 100 | 99 |
| Localized hypokinesia | 4 | 5 | 80 | 100 | 100 | 100 | 100 |
| Global hypokinesia | 13 | 16 | 81 | 100 | 100 | 99 | 99 |
| Right ventricular dilatation | 129 | 132 | 98 | 100 | 100 | 98 | 99 |
| Right atrium | | | | | | | |
| Right atrial dilatation | 129 | 132 | 98 | 100 | 100 | 98 | 99 |
| Right atrial thrombus | 1 | 1 | 100 | 100 | 100 | 100 | 100 |
| Septal dynamics | | | | | | | |
| Normal | 176 | 164 | 100 | 91 | 93 | 100 | 96 |
| Hypokinetic | 72 | 81 | 89 | 100 | 100 | 96 | 97 |
| Paradoxical motion | 52 | 55 | 95 | 100 | 100 | 99 | 99 |
| Valvular lesions | | | | | | | |
| Vegetation | 17 | 20 | 85 | 100 | 100 | 99 | 99 |
| Calcification | 7 | 7 | 100 | 100 | 100 | 100 | 100 |
| Prolapse | 1 | 2 | 50 | 100 | 100 | 100 | 100 |
| Valve prosthesis | 2 | 2 | 100 | 100 | 100 | 100 | 100 |
| Probable stenosis of aortic valve | 4 | 3 | 100 | 100 | 75 | 100 | 100 |
| Probable stenosis of mitral valve | 7 | 6 | 100 | 100 | 86 | 100 | 100 |
| Probable incompetence of tricuspid valve | 41 | 137 | 30 | 100 | 100 | 63 | 68 |
| Probable incompetence of mitral valve | 56 | 71 | 79 | 100 | 100 | 94 | 95 |
| Probable normal mitral valve | 233 | 218 | 100 | 82 | 94 | 100 | 95 |
| Probable normal tricuspid valve | 259 | 163 | 100 | 30 | 63 | 100 | 68 |
| Pericardial effusion | | | | | | | |
| Mild | 22 | 25 | 88 | 100 | 100 | 99 | 99 |
| Moderate | 4 | 4 | 100 | 100 | 100 | 100 | 100 |
| Massive | 3 | 3 | 100 | 100 | 100 | 100 | 100 |
| Massive with cardiac tamponade | 2 | 2 | 100 | 100 | 100 | 100 | 100 |
| Aortic aneurysm | 1 | 1 | 100 | 100 | 100 | 100 | 100 |
| Inferior vena cava | | | | | | | |
| Normal volume status | 210 | 210 | 100 | 100 | 100 | 100 | 100 |
| Intravascular volume depletion | 19 | 19 | 100 | 100 | 100 | 100 | 100 |
| Increased right atrial pressure | 57 | 57 | 100 | 100 | 100 | 100 | 100 |
| Not possible to assess inferior vena cava using sonography | 14 | 14 | 100 | 100 | 100 | 100 | 100 |
| Limited compression ultrasonography | | | | | | | |
| Normal | 35 | 32 | 100 | 99 | 91 | 100 | 99 |
| Deep venous thrombosis | 15 | 18 | 83 | 100 | 100 | 99 | 99 |

NPV, negative predictive value; PPV, positive predictive value; ACC, accuracy.

**Table 5 Range of sensitivity, specificity, positive predictive value, negative predictive value, and ACC of basic echocardiography**

| Variables | Mean±SD (%) | Minimum–maximum |
|---|---|---|
| PPV | 97±7 | 63–100 |
| NPV | 98±6 | 63–100 |
| Sensitivity | 93±14 | 30–100 |
| Specificity | 97±12 | 30–100 |
| ACC | 98±7 | 68–100 |

NPV, negative predictive value; PPV, positive predictive value; ACC, accuracy.

has been increasingly used by intensivists since the 1990's as it is a noninvasive tool and can be applied in fast and guided manner at the bedside [7].

GDE allows identification of imminently life-threatening conditions, where an intervention may be life-saving, such as pericardial tamponade, major valve failure, severely reduced LV function, or massive pulmonary embolism [4].

In the current study, basic echocardiography showed that 91/300 (30.3%) patients had normal echocardiogram, whereas 209/300 (69.7%) patients had cardiac abnormalities. In addition to this, basic echocardiography had an impact on the diagnosis; either confirmed, added, or changed the diagnosis.

Basic echocardiography added unsuspected serious conditions to the diagnosis in 33 (11%) patients; five patients with massive pericardial effusion, 22 patients who required inotropics because of dilated cardiomyopathy in 11 patients and ischemic cardiomyopathy in 11 patients, five patients with DVT, and one patient with aortic aneurysm. It also confirmed seven patients with massive pulmonary embolism and 13 patients with DVT.

The criteria was suggestive of massive pulmonary embolism in 7/300 (2.3%) patients in the form of dilated RV in 7/7 (100%) patients, dilated right atrium in 7/7 (100%) patients, D-shaped LV in 7/7 (100%) patients, paradoxical septal motion in 7/7 (100%) patients, localized hypokinesia of the RV (McConnel sign) in 5/7 (71.4%) patients, plethoric IVC in 7/7 (100%) patients.

The study conducted prospectively by Dresden *et al.* [8], upon 146 patients with suspected or confirmed pulmonary embolism between June 2009 and August 2011 in the Emergency Department (ED) at Boston Medical Center, USA where bedside echocardiography was done, reported that 30 of 146 patients had pulmonary embolism. Of the 30 patients with pulmonary embolism, dilated RV was identified in 15 patients, six patients with McConnell's sign, and eight patients with paradoxical septal motion. Eleven of 146 patients had RV hypokinesia, of whom 10 patients had a confirmed diagnosis of pulmonary embolism.

The study conducted prospectively by Weekes *et al.* [9], upon 116 normotensive pulmonary embolism patients where qualitative GDE for RV dysfunction was done: RV enlargement (diameter greater than or equal to that of the LV), severe RV systolic dysfunction and septal bowing was assessed and compared with comprehensive echocardiography. The study was conducted in the ED at Carolinas Medical Center in Charlotte, USA from July 2014 to July 2015. They reported that 26 of 116 (22%) patients had RV dysfunction on comprehensive echocardiography.

In addition to this, the study conducted by Cho *et al.* [10], as meta-analysis upon patients with acute pulmonary embolism in an attempt to evaluate RV dysfunction by echocardiography as a prognostic factor in stable patients with acute pulmonary embolism, reported that 1223/3283 (37.3%) of patients had dilated RV, whereas 2060/3283 (62.7%) had normal RV function.

In addition to this, basic echocardiography confirmed normal volume status in 210/300 (70%) patients, intravascular volume depletion in 17/300 (5.7%) patients, increased right atrium pressure in 14/300 (4.7%) patients, and lower limb deep venous thrombosis in 13/50 (26%) patients.

This was in agreement with the study conducted prospectively by Laursen *et al.* [11], on 139 adult patients with respiratory complaints admitted in the Medical ED at Odense University Hospital, Denmark between November 2010 and May 2011, which reported that IVC sonography was normal in 89 (64%) patients, intravascular volume depletion in 15 (11%) patients, increased right atrium pressure in 13 (9%) patients, and difficulty in assessing IVC in 22 (16%) patients.

On the contrary, with Laursen *et al.* [11], LCU was performed in 135/139 (97.1%) patients; in the remaining four patients, 4/139 (2.8%), one of the popliteal veins could not be visualized using LCU. LCU was normal in 130 (93.5%) patients. Signs of DVT were found in five (3.6%) patients, of whom diagnosis was confirmed by audit in three patients and two patients were false positive; one patient previously had DVT and the other patient had longstanding intravenous drug abuse and recurrent phlebitis.

The results of this study showed that basic echocardiography added localized hypokinesia, suggestive of ischemic cardiomyopathy, in 28/300 (9.3%) patients, global hypokinesia, suggestive of dilated cardiomyopathy, in 35/300 (11.7%) patients, LV hypertrophy, suggestive of hypertensive heart disease, in 8/300 (2.7%) patients.

This was in agreement with Laursen *et al.* [11], where normal echocardiogram was found in 59 (42%) patients, normal LV systolic function in 110 (79%) patients, moderate LV systolic dysfunction in seven (5%) patients, and severe LV systolic dysfunction in eight (6%) patients.

On the contrary, with Laursen *et al.* [11], marked dilatation of the LV was found in three (2%) patients, markedly hypertrophic LV in 41 (30%) patients, and hyperkinetic LV in 26 (19%) patients.

In the current study, basic echocardiography changed the diagnosis by exclusion of infective endocarditis in 18/300 (6%) patients, lower limb DVT in 32/300 (10.7%) patients, ischemic cardiomyopathy in 3/300 (1%) patients, massive pulmonary embolism in 3/300 (1%) patients, and dilated cardiomyopathy in 2/300 (0.7%) patients.

Basic echocardiography had an impact on the plan of management, where findings of basic echocardiography supported the use of anti-ischemic measures in 8/300 patients with ischemic cardiomyopathy. Fluid resuscitation was supported in 17/300 patients. Fluid restriction was supported in 6/300 patients because of ischemic cardiomyopathy, in 2/300 patients because of dilated cardiomyopathy, in 2/300 patients because of mitral stenosis and in 1/300 patient because of right-sided heart failure. Therapeutic anticoagulant prescription was supported in 16/300 patient due to lower limb DVT in nine patients, massive pulmonary embolism in three patients, lower limb DVT and massive pulmonary embolism in four patients.

Therapeutic anticoagulants were added to 8/300 patients (lower limb DVT in five patients, right atrial thrombus in one patient, LV thrombus in one patient, and left atrial spontaneous echo contrast because of severe mitral stenosis in one patient). Anti-ischemic measures were added to 28/300 patients. Inotropics were added in 22/300 patients (dilated cardiomyopathy in 11 patients and ischemic cardiomyopathy in 11 patients). Diuretics were added to 5/300 patients with dilated cardiomyopathy, 7/300 patients with ischemic cardiomyopathy, 10/300 patients with right-sided heart failure, and 5/300 patients with mitral stenosis.

Surgical intervention (valve repair or valve replacement) was recommended in 20/300 patients with persistent infective endocarditis, and in 4/300 patients with tight mitral stenosis secondary to rheumatic heart disease. Pericardiocentesis was performed in 2/300 patients with cardiac tamponade. Thrombolysis with streptokinase was prescribed in 7/300 patients with massive pulmonary embolism.

Fluids were discontinued in 10/300 patients because of echocardiographic evidence of ischemic cardiomyopathy, in 6/300 patients because of dilated cardiomyopathy, and in 3/300 patients because of tight mitral stenosis (MS) in rheumatic heart disease. Anticoagulants were discontinued in 2/300 patients because of diagnosis of infective endocarditis and in 1/300 patient after exclusion of lower limb DVT. Antiarrhythmics were discontinued in 1/300 patient because of detection of right atrial thrombus. Inotropics were discontinued in 1/300 patient because of severe aortic stenosis.

Manasia *et al.* [2] conducted a prospective study on 90 critically ill patients admitted in the surgical ICU of an academic medical center. After initial cardiac clinical assessment, a limited trans-thoracic echocardiography (TTE) was performed by an intensivist to assess LV size and function, to rule out significant pericardial effusions, and to estimate intravascular volume status. They reported that GDE added new cardiac information and changed the management in 33 of 90 (37%) patients. The changes included changes in the management of intravascular fluid compartment, where intravenous fluids were added in 2/33 patients and stopped in 6/33 patients, use of inotropes in 11/33 patients, and use of vasopressors in 2/33 patients. Before the GDE examination, LV systolic function was assumed to be normal in 79% of the patients, but GDE showed that only 51% of patients had normal LV function. Limited TTE added valuable information, but did not significantly affect the immediate management in additional 48% of patients.

By the end of this current study, comparison between basic echo findings as done by the investigator (pulmonologist) and standard echo findings as done by the expert (cardiologist) showed that basic echo was able to read the whole finding data as compared with standard echo, with mean sensitivity, specificity, PPV, NPV, and accuracy of 93, 97, 97, 98, and 98%, respectively, except with probable incompetent and probable normal tricuspid valve; the standard echo had the upper hand, where the basic echo at probable incompetence of tricuspid valve had minimum sensitivity, NPV, and ACC level, 30, 63, and 68%, respectively, even with 100% PPV and specificity, whereas at probable normal tricuspid valve, it showed minimum PPV, specificity, and ACC, 63, 30, and 68%, respectively, even with 100% sensitivity and NPV.In comparison to our study, Alexander *et al*. [12] conducted a study on patients scheduled for standard echocardiography as part of clinical care and underwent GDE within 24 h to assess four common clinically important diagnoses. The agreement between GDE and standard echocardiography was 75% for LV dysfunction (ejection fraction <55%), 79% for moderate or severe mitral regurgitation, 92% for aortic valve thickening or immobility, and 98% for moderate or massive pericardial effusion.

Similarly, Dresden *et al.* [8] performed a prospective observational study on convenience samples of the ED patients with suspected or confirmed pulmonary embolism, from June 2009 to August 2011. The study was performed in the ED at Boston Medical Center, USA and reported that; an expert cardiac sonographer, blinded to all clinical information, independently reviewed the recorded echocardiographic images of all patients, and there was 100% observed agreement in the identification of dilated RV and RV dysfunction, whereas there was 96% overall agreement in all images.

In addition to this, the study conducted prospectively by Moore *et al*. [13], upon 51 adult patients with symptomatic hypotension at an urban teaching ED, between 1 April and 1 September, 2000 reported that comparison between the emergency physician versus the primary cardiologist for LV ejection fraction estimation yielded 84% agreement between them.

Manasia *et al*. [2] reported that a diagnostic limited TTE was performed successfully by intensivists in 94% of patients and interpreted correctly in 84%.

## Conclusion

In a critically ill patient, basic echocardiography can readily provide adequate informations to get a successful diagnosis and can diagnose life-threatening conditions missed at the primary assessment in patients admitted with acute respiratory symptoms. Basic echocardiography can be also used as a monitoring tool to guide management in critically ill patients. IVC sonography provides a valuable tool and more practical approach in assessing intravascular volume status and guidance of fluid and vasopressor therapy for critically ill patients. LCU was considered to be useful in thromboembolic diseases with potential lethal consequences. Standard echocardiography is complementary to basic echocardiography in valvular lesions, especially tricuspid valve lesions.

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**Conflicts of interest**

There are no conflicts of interest.

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