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ORIGINAL ARTICLE

The Impact of Right Ventricular Dysfunction on Length of Hospital Stay in Patients with Acute Heart Failure

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ABSTRACT

Background: Hospital length of stay (LOS) is a key determinant of heart failure hospitalization costs and performance of medical care quality. Right ventricular (RV) dysfunction predicted poor outcome in patients with acute heart failure (AHF). To study the effect of right ventricular function on length of hospital stay as a predictor in patients with acute heart failure.

Methods: A prospective cohort study was conducted in CCUs in Zagazig University Hospital and Shark El Madina Hospital from September 2019 to February 2020, we included in this study ٩٩ patients admitted with AHF. Clinical data and baseline RV function assessed by tricuspid annular plane systolic excursion (TAPSE) and S` velocity were collected. Clinical comorbidities including worsening renal function (WRF) were monitored during hospitalization. The primary outcome was hospital LOS.

Results: There was significant correlation between WRF and poor outcome in patients with AHF including prolonged LOS. There is significant correlation between right ventricular systolic dysfunction identified by TAPSE<16 mm and S` <9.5 cm/sec and poor outcome in patients with acute heart failure including prolonged LOS.

Conclusion: Right ventricular (RV) systolic dysfunction as assessed by TAPSE and S` velocity was an independent predictor of longer LOS in AHF patients. Right ventricular diastolic dysfunction had statistically significant positive correlation as regard poor outcome in patients with AHF. WRF had high prevalence among patients with AHF and associated with poor outcome in AHF patients and prolonged LOS.

Keywords: Heart, Failure, Right, Ventricle.

INTRODUCTION

Heart failure (HF) is a clinical condition that results from pathological and functional disorders characterized by common symptoms (e.g. shortness of breath, swelling of the ankles and fatigue) both with and without signs that result in reduced cardiac performance to meet body's needs, which may be followed by increased intracardiac pressure throughout relaxation or stress.. **[1]** HF normally categorized by left ventricular systolic function as those with normal LVEF [that seem to be ≥ 50 per cent; HF with maintained EF (HFpEF)] as those with decreased LVEF [that seem to be < 40 per cent; HF with decreased EF (HFrEF)] and HF with midrange LVEF [that seem to be ≥ 40-49 per cent; HF with midrange EF (HFmrEF)]. **[2]** Acute heart failure (AHF) is a medical entity in which patients develop fast / progressive aggravation of HF symptoms and signs and considered a major reason of hospital admission in HF patients despite significant advances in diagnosis and treatment. **[3]** Length of hospital stay (LOS) is described as the number of days of hospital stay from the first day of entry to the day of discharge. Extremely long LOS is linked to poor results in the quality of healthcare and increased rates of eventual surrender and deaths. **[4]** Many recognized medical comorbidities for extended LOS involve acute stroke, worsening renal function (WRF), problems of the respiratory system needing special care, atrial fibrillation and nutritional problems. **[5]** Right ventricular (RV) systolic malfunction is also said to be in relation with reduced outcomes in HF patients and decreased left ventricular systolic capacity. Although RV dysfunction was largely investigated in stabilized chronic HF, it had a prognostic significance in AHF patients either with midrange

or stabilized systolic function. **[6], [7]** It is generally accepted that there's still a prognostic benefit of RV dysfunction as measured by 2D Transthoracic Echocardiogram (TTE) in estimating longer LOS and worse outcomes in AHF patients. **[8]**

Aim and objectives: To study the effect of right ventricular function on length of hospital stay as a predictor in patients with acute heart failure.

Subjects and methods: Technical design:

Study design: A prospective cohort study, carried out in the period from September 2019 to February 2020 on 99 patients suffering from AHF and admitted in Cardiology care units in Zagazig University Hospital and Shark El Madina Hospital. Patients have been categorized into two groups Group (A) included patients with AHF and normal right ventricular systolic function while Group (B) included patients with AHF with right ventricular systolic dysfunction. Inclusion criteria included patients with Acute/rapid deterioration in symptoms and/or signs of heart failure that require medical intervention according to latest European Society of Cardiology recommendations puplished in 2016 and their LOS from 3 to 45 days. On the other side, exclusion criteria included patients suffering from cardiac tamponade or aortic dissection or with evidence of acute coronary syndrome, acute pulmonary embolism.primary/ organic tricuspid regurge, LOS less than 3 days or longer than 45 days, End-Stage Renal Disease (ESRD) on regular hemodialysis or who died during hospitalization course.

METHODS

Criteria for admission of AHF patients was established according to the latest recommendations of the European Society of Cardiology (ESC) published in 2016. Detailed full history was taken from all patients with stress on age, sex, occupation, marital status, residence, clinical characteristics and the laboratory data collected during hospital admission. Complete clinical examination was done with specific concentration during the general examination on assessment of the general condition and vital signs. Cardiac examination was done involving inspection, palpation, percussion, and auscultation to detect murmurs and additional sounds and pulmonary rales. We performed some laboratory investigations during patient's hospital stay at (day 1, 3 and 5). Renal function tests (urea & creatinine) were done and WRF was considered as the occurrence of persistent increase ≥ 0.3 mg/dl or ≥ 25 % increase in serum creatinine from admission or baseline creatinine in CKD patients **[9]**. We also performed complete blood count (CBC), cardiac biomarkers (CK-MB & Troponin), electrocardiogram, echocardiography, a conventional echocardiography and Colour Doppler. Doppler and two-dimensional (2D) echocardiography were performed to assess the right ventricular function. Right ventricular systolic function was evaluated by tricuspid annular plane systolic excursion (TAPSE) and abnormal TAPSE <16 mm indicated RV systolic dysfunction **[10]**. Tissue Doppler-derived tricuspid lateral annular systolic velocity (s′) was assessed and s′ velocity <9.5 cm/s indicated RV systolic dysfunction **[11]**. Right ventricle diastolic dysfunction was evaluated and a tricuspid E/A ratio <0.8 suggested impaired relaxation and hence diastolic impairment while E/A ratio more than 2.1 and deceleration time <120 ms indicated restrictive filling and E/E` >6 indicated pseudo-normal RV filling pattern **[12]**. Right ventricular internal diameters by 2-dimensional echo was done. From apical four chamber view, end diastolic (ED) RV basal diameter of 41 mm indicated dilatation while (ED) RV mid cavity diameter of 35 mm indicated dilatation. End diastolic (ED) RV Longitudinal diameter of 86 mm indicated RV enlargement **[13]**. Inferior vena cava diameters and changes during respiration were obtained from subcostal view and assessed by M-Mode. **[14]**

Study outcome: The primary outcome of this research is LOS. It was defined as the average number of days in which the patients stayed in the hospital, from date of entry to the time of discharge .prolonged length of hospital stay is defined as more than six days based on (2006 to 2014 data from the Healthcare Cost and Utilization Project (H-CUP) National Emergency Department Survey.

Administrative considerations: Written informed consent was obtained from all participants and the study was approved by the research ethical committee of Faculty of Medicine, Zagazig University (Institutional Research Board IRB). The work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

STATISTICAL ANALYSIS

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level. The used tests were Chi-square test, Student t-test, Receiver operating characteristic curve (ROC), Regression and Pearson correlation coefficient.

RESULT

Table (1) shows distribution of studied cases according to demographic data including age and

sex. Table (2) shows Distribution of the studied cases according to right ventricular systolic echocardiographic parameters (TAPSE &S` velocity). Table (3) shows distribution of patients with right ventricular diastolic dysfunction in the study population. Table (4) shows that there is statistically significant positive correlation between right ventricular systolic dysfunction and poor outcome include prolonged length of hospital stay, need inotropic support, and need mechanical ventilation either invasive or non-invasive in patients with acute heart failure. Table (5) shows that there is statistically significant positive correlation between right ventricular diastolic dysfunction (RVDD) in patients included in our study population and poor outcome including prolonged length of hospital stay, need for inotropic support and need for mechanical ventilation. Table (6) shows there is statistically significant positive correlation between pneumonia in AHF patients and poor outcome including prolonged LOS and need for mechanical ventilation. Using cut off value ≤16 mm for TAPSE as assessment for right ventricular systolic function predicted prolonged length of hospital stay (≥6 days) with positive predictive value of 98.3, sensitivity of 73.42 and specificity of 95 as shown in Table (7).

Table (1): Distribution of the studied cases according to demographic data (n = 99).

	No.	%
Sex		
Male	58	58.6
Female	41	41.4
Age (years)		
Min. – Max.	45.0 – 88.0	
Mean ± SD.	64.06 ± 8.41	
Median (IQR)	65.0 (59.0 – 70.0)	

Qualitative data was represented as number and percentage.
Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR).

Table (2): Distribution of the studied cases according to right ventricular systolic echocardiographic parameters (n=99).

	No.	%
TAPSE (mm) (day1)		
<16	51	51.5
≥16	48	48.5
Min. – Max.	9.0 – 27.0	
Mean ± SD.	17.15 ± 3.61	
Median (IQR)	15.0 (14.0 – 19.0)	
S` (cm/sec) (day1)		
<9.5	51	51.5
≥9.5	48	48.5
Min. – Max.	8.0 – 10.0	
Mean ± SD.	9.17 ± 0.70	
Median (IQR)	9.0 (8.90 – 9.90)	

Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR).

Table (3): Distribution of the studied cases according to RVDD in day 1.

RVDD	No.	%
Total (n=99)	34	34.3
Group A (n=48)	0	0.0
Group B (n=51)	34	66.7

Quantitative data represented as number and percentage.

Table (4): Comparison between the two studied groups according to outcome.

Outcome	Group A (n = 48)		Group B (n = 51)		Test of Sig.	p
	No.	%	No.	%		
Length of hospital stay (days)						
Min. – Max.	3.0 – 9.0		4.0 – 14.0		t= 11.838*	<0.001*
Mean ± SD.	5.94 ± 1.62		10.31 ± 2.02			
Median (IQR)	6.0 (5.0 – 7.0)		10.0 (10.0 – 12.0)			
Need for inotropic support	11	22.9	46	90.2	χ^2= 45.823*	<0.001*
Need for mechanical ventilation	27	56.3	51	100.0	χ^2= 28.320*	<0.001*
NICPAP	26	96.3	21	41.2	χ^2= 22.397*	<0.001*
Invasive Ventilation	1	3.7	30	58.8		

Qualitative data was represented as number and percentage.
Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR).

Table (5): Relation between RVDD and outcome in total sample (n=99).

Outcome	RVDD				Test of Sig.	p
	Yes (n = 34)		No (n = 65)			
	No.	%	No.	%		
Length of hospital stay (days)						
Min. – Max.	6.0 – 13.0		3.0 – 14.0		t= 7.572*	<0.001*
Mean ± SD.	10.38 ± 1.69		7.05 ± 2.68			
Median (IQR)	10.0(5.0 – 7.0)		6.0(10.0 – 12.0)			
Need for inotropic support	34	100.0	44	67.7	χ^2= 13.942*	<0.001*
Type for mechanical ventilation						
NICPAP	15	44.1	32	72.7	χ^2= 6.555*	0.010*
Invasive Vent	19	55.9	12	27.3		

Qualitative data was represented as number and percentage.
Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR).

Table (6): Relation between pneumonia and outcome in study population

Outcome	Pneumonia				Test of Sig.	p
	No (n = 43)		Yes (n = 56)			
	No.	%	No.	%		
Length of hospital stay (days)						
Min. – Max.	3.0 – 11.0		4.0 – 14.0		t= 5.105*	<0.001*
Mean ± SD.	6.70 ± 2.39		9.34 ± 2.67			
Inotrope support	23	53.5	34	60.7	χ^2= 0.520	0.471
Type of mechanical ventilation	(n = 30)		(n = 48)			
NICPAP	27	90.0	20	41.7	χ^2= 18.009*	<0.001*
Invasive Vent	3	10.0	28	58.3		

Qualitative data was represented as number and percentage.
Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR).

Table (7): Agreement (sensitivity, specificity) TAPSE (mm) (day1) to predict prolonged length of hospital stay (≥6 days).

	AUC	p	95% C. I		Cut off#	Sensitivity	Specificity	PPV	NPV
			LL	UL					
TAPSE (mm) (day1)	0.845	<0.001*	0.741	0.949	≤16	73.42	95.0	98.3	47.5

Student t-test, Receiver operating characteristic curve (ROC), Regression and Pearson correlation coefficient tests were used.

DISCUSSION

In this work, we sought to study the relationship between right ventricular dysfunction and length of hospital stay (LOS) in acute heart failure patients. Establishing such relationship could urge physicians to give more attention to right ventricular dysfunction aiming at reducing length of hospital stay (LOS) in such patients.

Clement and colleagues performed a study to prove that RV dysfunction is an important indicator for poor outcomes in patients with dilated cardiomyopathy (DCM). 34 patients with RV dysfunction identified as TAPSE ≤15 mm; 102 patients (group 2) retained RV function. **[15]**

In disagreement with our study, **Clement Vennera et al**, included more male patients (about two-third) compared to 58.6% in our study. Mean age of studied patients was 64.06± 8.41 years in our study compared to 59.0 ± 13.2 years in Clement Vennera et al study.

On the other hand our study was performed on patients with broad range of left ventricular systolic function either preserved , mid- range and reduced left ventricular systolic function but Clement Vennera, et al study restrict their study for patients with acute heart failure with reduced left ventricular systolic function (LVEF <45 %).

Ghio and colleagues performed a study to prove that RV dysfunction estimated by TAPSE had poor outcomes in heart failure patients with decreased left ventricular systolic function LVEF<35%. **[16]**

Our study was concordant with these results in considering TAPSE as important tool for assessment right ventricular systolic function and independent prognostic factor for patients with AHF with reduced left ventricular systolic function LVEF <35%.

Ghio S ,et al study was carried out on patients with reduced left ventricular systolic function but our study included broad range LV systolic function and in our study we also assessed right ventricular systolic function by another parameter (S` velocity) due to limitations of TAPSE and also assessed right ventricular diastolic dysfunction which was`t investigated in **Ghio S ,et al study**.

In a study performed by **Damy and colleagues**, the prognosis of RV function was assessed by TAPSE in heart failure patients (CHF) with manifestations of a variety of symptoms (LVEF) unidentified. **[17]**

Our study was also in agreement with these results that proved that, in patients with CHF, low values for TAPSE are common, especially in those with reduced LVEF and considered an important prognostic factor for patients with acute decompensated heart failure.

Thomas and colleagues conducted a meta-analysis trial to analyze the impact of right ventricular dysfunction measured by TAPSE < 16 mm, RV S < 9.5 and fractional area change (FAC) < 35% and pulmonary hypertension (PH) with prognosis involving rates of mortality and morbidity in AHF patients with intact systolic function (HFpEF). **[18], [19]**

This meta-analysis study investigated the influence of RV dysfunction measured by various echocardiographic parameters and its relationship to poor outcomes in HFpEF patients. **[20]**

In this meta-analysis with strict HFpEF parameters, the incidence of RV dysfunction was 28 per cent for TAPSE, 18 per cent for FAC and 21 per cent for RV S. TAPSE (HR 1.26 / 5 mm decrease, P <0.0001), FAC (HR 1.15 / 5 percent decrease; P <0.0001), increase; P <0.0001) were both inevitably correlated with fatalities. HRs for RV S have not been registered. **[21]**

Our study was concordant with the study of Thomas and colleagues that proved that RV dysfunction was highly prevalent in HFpEF. The prevalence of RV dysfunction was dependent on the method and cut-offs used for its assessment and associated with poor outcome in patients with heart failure with preserved systolic function (HFpEF) but our study was performed on patients with HF either with preserved or mid-range and reduced LVEF.

This study presented data on the RV feature in HFpEF vs. HFrEF, referring to a control group without HF, all prospectively selected from a diverse ethnic groups Asian community that used a standard methodology. The incidence of RV dysfunction, measured by TAPSE or RV deformation scanning, reached up to 42% in HFpEF, 4 times the prevalence of controls, but also more in HFrEF in 2/3 of patients. **[22]**

In their review of 105 cases with systolic HF, Yu and Sanderson did a study which revealed right ventricular diastolic dysfunction (RVDD) to be occurring in 21 percent of participants as evaluated

by echocardiography. Even though a low-powered research, the researchers concluded that RVDD was just an independent indicator of nonfatal hospitalizations for unstable angina or HF, while it was not found to become a predictive value for mortality, alone or in association with left ventricular diastolic dysfunction. **[23], [24], [25]**

Our study was concordant with the study of Yu and Sanderson regarding RVDD considered as independent prognostic factor in patient with acute heart failure and related to prolonged LOS.

The greater prognostic value of the TAPSE and S 'velocity relative to other echocardiographic metrics of the RV systolic function seems to be that the decreased TAPSE and S' velocity truly represents a significant impairments of RV function, since the systolic shortening of the RV from base to apex gives evidence on not only the process of emptying of the RV but also on the driving force acting on the systolic.

Our findings regarding pneumonia were concordent with **Alexander Jobs, et al** that performed a study on 1939 patients with acute decompensating heart failure (ADHF) this study carried out in department of cardiology at Germany and they proved that concomitant pneumonia was relatively common in patients with ADHF and associated with poor outcome including longer length of hospital stay (LOS) and increased rates of in-hospital mortality**. [26]**

Conclusion and recommendations:

RV systolic dysfunction as measured by TAPSE and S 'velocity had been an important indicator of long LOS in ADHF patients. RVDD has a strong association with poor outcomes in patients with AHF. WRF had an increased incidence in patients with AHF and correlated with low outcomes in patients with AHF and extended LOS. Right side evaluation in 2-D echocardiography must be regularly conducted as a left side evaluation. RV dysfunction must be treated as left ventricular malfunction.

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