

# Echocardiographic Assessment and Prognostic Role of Right Ventricular Function in Chronic Heart Failure Patients in Cameroon

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## Abstract

**Aim:** this study aimed to assess right ventricular (RV) function by echocardiography in chronic heart failure (CHF) patients, and its prognostic role.

**Materials and methods:** we conducted a 1-year longitudinal study. Participants were aged  $\geq 21$  years, with stable CHF. RV systolic and diastolic functions were assessed with bidimensional, time-motion, and Doppler modes. 6-months outcomes evaluated were all-cause death, or heart failure (HF) hospitalization.

**Results:** we included 82 patients with a median age of 63 years. The median left ventricular ejection fraction was 36 %. RV systolic dysfunction was observed in 64.6% of patients, while 52.4% had RV diastolic dysfunction. The 6-months mortality rate was 13.4%, and 54.9% had at least 1 HF hospitalization. RV systolic dysfunction was only significantly associated to HF hospitalizations (OR = 2.75 (1.04 – 7.28); p = 0.039).

**Conclusion:** RV systolic dysfunction is frequent and increases the risk of hospitalization in Cameroonian CHF patients

**Key Words:** chronic heart failure; right ventricular function; echocardiography; prognosis

## Introduction

Chronic heart failure (CHF) is a major public health problem worldwide with an increasing prevalence [1,2]. In 2017, the estimated number of people living with CHF in the world was 64 million [3]. Despite significant improvements in the management and prevention of CHF over the past decades, its related mortality rate remains high. In a community-based study in the United States, Tsao et al reported a mortality rate of 67% for both heart failure with and without reduced ejection fraction during a follow-up period of 20 years [4]. Chronic left heart failure is a complex clinical syndrome which often leads, during its evolution, to right ventricular (RV) dysfunction, resulting from post-capillary pulmonary hypertension thus increasing afterload [5]. However, in most CHF studies, the left heart function is always assessed, while the RV function is often overlooked, although it plays an important role. Recent studies have shown that RV function was a significant predictive factor of mortality related to CHF [6–9]. Consequently, right ventricular

function assessment should be an integral part of the management of CHF patients. The right ventricle has a complex anatomy and function, compared to the left ventricle, and thus is better assessed by cardiac magnetic resonance imaging, which is considered as the gold standard method, and sometimes right heart catheterization [10]. However, these tools are not readily available nor accessible in low-and-middle income countries such as Cameroon. We therefore rely on echocardiographic assessment of the right ventricle which is challenging because of the above-mentioned complex morphology, not allowing a good geometric modelization. Nevertheless, a multiparametric echocardiographic approach may help for a better characterization of the global function of the right ventricle [9,10]. This study aimed to assess right ventricular function using echocardiography and to determine its prognostic role in CHF patients in the Yaoundé and Garoua general hospitals.

## Materials and methods

### Study design and setting

We conducted a longitudinal study during 12 months, spanning from August 2023 to July 2024, in the cardiology units of the Yaoundé and Garoua general hospitals, two reference hospitals in Cameroon.

### Participants and sampling

We included patients aged 21 years or more, with chronic stable left heart failure, irrespective of the left ventricular ejection fraction. We excluded patient with isolated right heart failure, congenital heart failure, prosthetic heart valve, cardiac pacemaker, pericardial effusion and those with incomplete echocardiographic data.

We performed a non-probabilistic consecutive sampling.

### Data collection

We collected data using a predesigned sheet. The data included:

- Sociodemographic characteristics: age, gender, revenue.
- Comorbidities: hypertension, diabetes, dyslipidemia, chronic kidney disease, hyperuricemia, human immunodeficiency syndrome, cancer, pulmonary embolism, anemia, tobacco smoking and alcohol consumption.
- Heart failure stage using the New York Heart Association (NYHA) classification
- pharmacologic treatment of CHF and adherence assessed using the Morisky's questionnaire.
- Blood pressure, heart rate, weight and height.

We used two echocardiographic machines. A General Electric Vivid T9 and a Hitachi Aloka. All the measurements were performed following the 2015 recommendations of the American Society of Echocardiography and the European Association of Cardiovascular Imaging [11].

Left ventricular ejection fraction (LVEF) was measured using the Simpson method. The left ventricular diastolic function was graded using the Appleton classification.

The RV systolic function was assessed using a combination of parameter: two-dimensional fractional area change (2D-FAC), tricuspid annular plane systolic excursion (TAPSE), DTI-derived tricuspid lateral annular systolic velocity (S') and right ventricular index of myocardial performance (RIMP) or Tei index.

- **The 2D-FAC** was calculated using the formula:  $FAC = ((EDA - ESA)/EDA) \times 100$ . It was considered pathological when  $< 35\%$ . The end-diastolic (EDA) and end-systolic (ESA) were obtained in the apical 4-chamber view by contouring the endocardium in diastole and systole, and including trabeculae, papillary muscles and moderator band in the RV cavity.
- **The TAPSE** was measured in the apical 4-chamber view by time-motion mode with the cursor aligned with the lateral tricuspid annulus. It was considered as pathological when  $< 17\text{mm}$ .
- **The DTI-derived tricuspid lateral annular systolic velocity (S')** was measured in the apical 4-chamber view by DTI mode. The cursor was optimally aligned with the lateral tricuspid annulus. It was considered pathological when  $< 9.5\text{ cm/s}$ .
- **The RIMP or Tei index** was calculated using the formula:  $RIMP = (IVCT + IVRT)/ET$ . Measurements were done in the apical 4-chamber

view using DTI velocity at the lateral tricuspid annulus. The isovolumic contraction time (IVCT), isovolumic relaxation time (IVRT), and ejection time (ET) intervals were measured from the same heartbeat. Value of Tei index  $> 0.54$  were considered as pathological.

RV diastolic function was assessed using the tricuspid E/A and E/E' ratios.

- **Tricuspid E/A ratio:** obtained by measuring tricuspid E and A velocities in the apical 4-chamber view by pulse wave Doppler with the cursor placed at the tip of the tricuspid valve leaflets. It was considered as pathological when  $< 0.8$  or  $> 1.2$ . The E wave deceleration (EDT) time was also measured.

- **Tricuspid E/E' ratio:** the E' wave velocity was obtained in the apical 4-chamber view by DTI mode. The cursor was aligned with the lateral tricuspid annulus. It was considered pathological when  $> 6$

RV diastolic dysfunction stages were classified as follows:

- Altered relaxation: E/A ratio [Less-than sign](#) 0.8
- Pseudo-normal pattern: E/A ratio between 0.8 and 1.2, and E/E' ratio  $> 6$
- Restrictive pattern: E/A ratio  $> 1.2$  and EDT  $< 120\text{ms}$ .

Furthermore, we made an echocardiographic estimation of pulmonary vascular resistance (PVR) by dividing the tricuspid regurgitation velocity (TRV) by the velocity-time integral in the right ventricular outflow track (RVOT):  $PVR = TRV/VTI (RVOT)$ . PVR was expressed in Woods units, and considered abnormal when it was  $> 2$  [12].

### Follow-up

The participants were followed-up in office consultation on M1, M3 and M6, and by phone calls on M2, M4 and M5.

During office consultations, data collected during were the following:

- Occurrence or aggravation of signs and symptoms of heart failure, and change in vital parameters leading to the modification of heart failure treatment or hospitalization.
- Medication adherence: monitored using 8-item Morisky medication adherence scale. A score of 8 indicated a high adherence, 6 to 7 medium adherence, and [Less-than sign](#) 6 low adherence.

During phone calls, we asked the participants if they had symptoms of heart failure, and encouraged them to have good medication adherence.

Participants who did not present for office consultations, and who were unreachable on phone were considered as lost to follow-up.

Prognostic criteria were all-cause mortality, and hospitalization for heart failure.

### Statistical analysis

We performed statistical analysis using Statistical Package for Social Sciences software version 23.0. We used the Chi-square test for the comparison of proportions. The Fisher exact test was used where appropriate. The Mann Whitney test was used for the comparison of medians, logistic regression for multivariate analysis. We analyzed factors associated to RV systolic and diastolic dysfunction. The first step consisted of the univariate analysis including the following variables: gender, age, heart failure duration, left ventricular ejection fraction, left ventricular diastolic dysfunction, pulmonary artery systolic pressure, pulmonary vascular resistance, basal RV diameter, and medication adherence. The second step was a logistic regression of all variables with significant p-values in univariate analysis. Data of participants lost to

follow-up were not included in mortality analysis. We also did not include in the analysis of hospitalization the data of participants who had never been hospitalized before their lost to follow-up. A p-value [Less-than sign](#) 0.05 was considered as statistically significant.

### Ethical considerations

This study was conducted in accordance to with the declaration of Helsinki. We obtained an ethical clearance N°1007/UY1/FMSB/VDRC/DAASR/SCD from the institutional ethical review board of the faculty of medicine and biomedical sciences of the university of Yaoundé I.

### Results

We included 82 patients (48.8% women) in the study. The median age was 63 [52 – 71] years. The baseline characteristics of the study population are presented in table I. Hypertension was the most frequent comorbidity. Hypertensive and ischemic cardiopathies as well as dilated cardiomyopathy were the most frequent etiologies of CHF. Most participants were classified NYHA II. Two third of the participants had heart failure with reduced ejection fraction (HFrEF). All classes of guideline-directed medical therapy were used in various proportions, and medication adherence was high in two third of participants.

Variables	Categories	Number (N=82)	Percentage (%)
<b>Gender</b>	Male	42	51.2
	Female	40	48.8
<b>Left heart failure etiologies</b>	Hypertensive cardiopathy	43	52.4
	Ischemic cardiopathy	21	25.6
	Dilated cardiomyopathy	10	12.2
	Valvular heart disease	5	6.1
	PPCM	3	3.7
<b>NYHA stage</b>	II	50	61.0
	III	26	31.7
	IV	6	7.3
<b>LVEF</b>	< 40	53	64.6
	≥ 40	29	35.4
<b>Medications</b>	Diuretic	74	89.0
	Betablocker	69	83.1
	ACEi/ARB	60	73.2
	MRA	42	50.6
	SGLT2i	23	27.7
	Sacubitril-valsartan	14	16.9
<b>Medication adherence</b>	High	52	64.4
	Medium	19	23.2
	Low	11	13.4
<b>Comorbidities</b>	Hypertension	61	74.4
	Low physical activity	48	58.5
	Alcohol consumption	20	24.4
	Diabetes	15	18.3
	Obesity	14	17.1
	Dyslipidemia	11	13.4
	Tobacco smoking	10	12.2
	Chronic kidney disease	8	9.8

**Table I:** Baseline characteristics of the study population

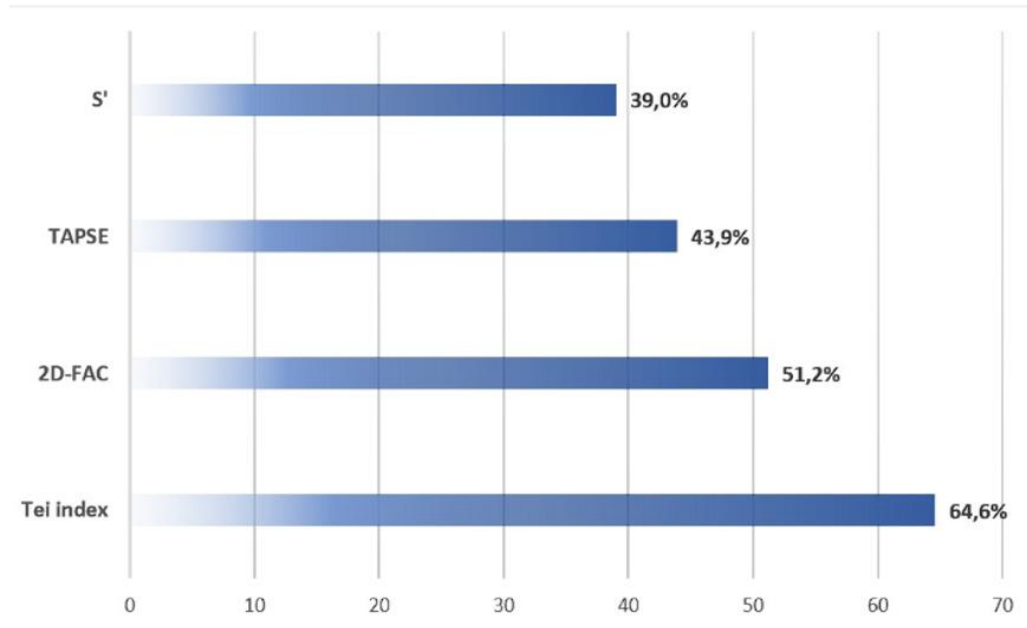
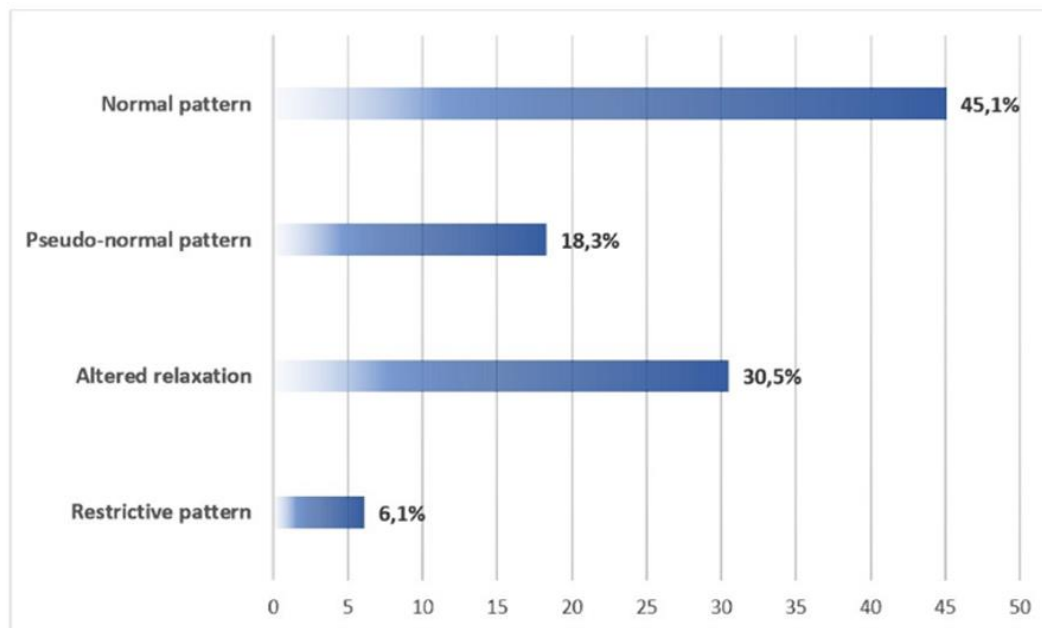
**PPCM:** peripartum cardiomyopathy **NYHA:** New York Heart Association **LVEF:** left ventricular ejection fraction **ACEI:** angiotensin converting enzyme inhibitor **ARB:** angiotensin receptor blocker **MRA:** mineralocorticoid receptor antagonist **SGLT2I:** sodium/glucose cotransporter 2 inhibitor

In **table II** we reported the findings of morphologic, and functional echocardiographic assessment of the right ventricle. There was no significant difference between men and women. Abnormalities of at least one parameter of RV systolic function were present in 53 participants (64.6%). The Tei index was the most frequently altered parameter

followed successively by the 2D-FAC, the TAPSE and the DTI-derived tricuspid lateral annular systolic velocity (**Figure 1**). RV diastolic dysfunction was present in 43 participants (52.4%) with abnormal relaxation in most cases (**Figure 2**).

Variables	Men	Women	<i>p</i>
<b>RV basal diameter</b>	40 [31 – 47]	35 [30 – 45]	0.348
<b>Proximal RVOT in PSLA</b>	32 [29 – 40]	32 [30 – 37]	0.662
<b>Proximal RVOT in PSSA</b>	34 [28 – 37]	33 [27 – 37]	0.670
<b>Distal RVOT in PSSA</b>	26 [22 – 28]	24 [21 – 26]	0.373
<b>PA diameter</b>	24 [20 – 28]	24 [20 – 26]	0.659
<b>Basal RV thickness</b>	4 [4 – 5]	4 [3 – 4]	0.067
<b>RV/LV ratio</b>	0,76 [0,62 – 0,98]	0,77 [0,63 – 0,92]	0.898
<b>RA surface</b>	19 [16 – 25]	19 [17 – 23]	0.686
<b>TAPSE</b>	18 [13 – 21]	17 [13 – 22]	0.762

S'	11,0 [8,0 – 12,9]	10,0 [8,3 – 13,0]	0.907
2D-FAC	32 [21 – 43]	34 [21 – 46]	0.534
Tei index	59 [45 – 73]	59 [46 – 79]	0.926
E/A ratio	0,89 [0,69 – 1,20]	1,07 [0,73 – 1,36]	0.269
E/Ea ratio	5 [4 – 7]	5 [3 – 6]	0.722
EDT	160 [116 – 216]	188 [119 – 276]	0.252

**Table II:** parameters of right ventricular morphologic and functional assessment**Figure 2:** Proportions of abnormal right ventricular systolic function parameters**Figure 2:** Proportion patterns of right ventricular diastolic function

At six months follow-up, half number of participants had presented at least one hospitalization for congestive heart failure. The triggers of decompensation were infections (41.0%), poor adherence to treatment (37.0%), anemia (11.0%), and arrhythmia (4.1%). The trigger of decompensation was unidentified in 6.9% of participants. The mortality rate was 13.4%. RV systolic dysfunction was significantly associated with

hospitalizations for heart failure but not to all-cause mortality (**Table III**). There was no significant association between RV diastolic dysfunction and neither hospitalizations for heart failure nor all-cause mortality. RV systolic dysfunction was independently associated with LVEF [Less-than sign](#) 40 [Percent sign](#) (**Table IV**).

	All-cause mortality		Hospitalizations	
	No (n=62)	Yes (n=11)	No (n=30)	Yes (n=45)
<b>RV systolic dysfunction</b>				
Yes	38 (61.3)	8 (72.7)	15 (50.0)	33 (73.3)
No	24 (38.7)	3 (27.3)	15 (50.0)	12 (26.7)
OR (95% CI)	1.68 (0.41 – 6.98)		2.75 (1.04 – 7.28)	
p	0.736		0.039*	
<b>RV diastolic dysfunction</b>				
Yes	36 (58.1)	4 (36.4)	17 (56.7)	23 (53.5)
No	26 (41.9)	7 (63.6)	13 (43.3)	20 (46.5)
OR (95% CI)	0.41 (0.11 – 1.56)		0.88 (0.34 – 2.25)	
p	0.207		0.788	

**Table III:** Assessment of the association between prognostic factors and right ventricular dysfunction

**RV:** right ventricular **OR:** odds ratio **CI:** confidence interval \*significant

	All-cause mortality		Hospitalizations	
	No (n=62)	Yes (n=11)	No (n=30)	Yes (n=45)
<b>RV systolic dysfunction</b>				
Yes	38 (61.3)	8 (72.7)	15 (50.0)	33 (73.3)
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Yes	36 (58.1)	4 (36.4)	17 (56.7)	23 (53.5)
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OR (95% CI)	0.41 (0.11 – 1.56)		0.88 (0.34 – 2.25)	
p	0.207		0.788	

**Table IV:** Multivariate analysis of factors associated with right ventricular systolic dysfunction

**RV:** right ventricular **OR:** odds ratio **CI:** confidence interval **LVEF:** left ventricular ejection fraction **PASP:** pulmonary artery systolic pressure

## Discussion

This study aimed to determine the prognostic value of RV function assessed by echocardiography in CHF patients in Cameroon, where other work-up such as cardiac magnetic resonance imaging, and biomarkers are not readily available, and most patients unable to afford them in the absence of universal health coverage. Our participants similarity as found by previous authors in Cameroon [13–16]; were relatively young with approximately 10 years difference as compared to CHF patients in high income countries [17,18]. This can be explained by the limited access to health services in Cameroon, which can lead to late management of risk factors, leading to early onset heart failure. Hypertension was the most frequent comorbidity. It is the predominant cardiovascular risk factor in Africa where its prevalence reaches 42% [19]. Hypertension which is asymptomatic at early stages often goes undiagnosed and undertreated in our milieu, leading inexorably to complications such as CHF. This fact can explain why hypertensive cardiopathy most prevalent in our sample, contrasting with the pattern in high income countries where ischemic heart disease is the leading cause of CHF [20]. Heart failure with reduced ejection fraction was more frequent in our study population, and corroborate the data from a large European registry reporting 60% of HFrEF phenotype [21]. Concerning RV systolic dysfunction, the prevalence we obtained is close to those reported by Meluzin et al in Czechia, and Menanga et al in Cameroon [13,22]. They reported respectively 70% and 81.6%. In contrary, Venner et al in France, and Shaker et al in Egypt found lower prevalences, respectively 25% and 48.7% [23,24]. These disparities may be explained by different study populations (only HFrEF patients included in the latter studies), and different definitions of RV systolic dysfunction. RV systolic dysfunction was based on --TAPSE, S' and 2D-FAC in the study of Shaker et al, while it was only based on TAPSE in the Study of Venner et al. Concerning RV

diastolic function, data in the literature is very scarce. However, Sumin et al in the USA also found in 2021 that approximately half of the participants with ischemic heart failure with preserved ejection fraction had RV diastolic dysfunction [25]. The multivariate analysis showed an association between RV systolic dysfunction and LVEF < 40%, similarly as Menanga et al in Cameroon, Venner et al in France, and Kjaergaard et al in Denmark, who also found such associations [13,23,26]. Data from the literature indicate all-cause mortality is higher in presence of RV systolic dysfunction, but in our study, only the rate of hospitalizations for heart failure was significantly increased. The absence of association with all-cause mortality is probably because of the short follow-up period, and small sample size. In a large study with 817 heart failure patients and a median follow-up of 4.1 years, Kjaergaard et al found that decreased TAPSE was independently associated with short- and long-term survival [26]. Venner et al also reported in a 2016 study of 136 patients with idiopathic dilated cardiomyopathy, after 2-years follow-up, that RV dysfunction was an independent predictor for major adverse cardiac events [23]. More recently in their study with 6-month follow-up of 195 patients with acute HFrEF, Shaker et al found 30.5% mortality rate, and that RV global longitudinal strain independently predicted poor-outcome defined as the composite of cardiovascular death, and hospitalization for worsening heart failure [24]. As concerns the question to know which parameter of RV systolic function is of best prognostic value, Gentile et al in a recent study including 1590 patients, showed that TAPSE and 2D-FAC were more accurate than S' in predicting cardiac and all-cause death in patient with heart failure with a LVEF < 50% [27]. Furthermore, they reported that the combination of the two parameters provides an incremental prognostic value.



## Study limitations

This study has some limitations. First as mentioned in the discussion section, our sample size and follow-up period were respectively small and short, thus decreasing the statistical power. Secondly, we were unable to perform RV strain and magnetic resonance imaging because of unavailability for the first modality, and financial constraints for the second.

## Conclusion

Chronic heart failure patients frequently present right ventricular dysfunction, particularly those with reduced left ventricular ejection fraction. Right ventricular systolic dysfunction was found to be independently associated with hospitalization for worsening heart failure, but not with all-cause mortality. Right ventricular function assessment should be systematically integrated in the management of heart failure patients.

## Author contributions

Hamadou B, Nganou-Gnindjio C-N, Oummoul Koulsoumi D, and Owona Ngabede A: study design. Oummoul Koulsoumi D: data collection. Djantio Noundou H J, Oummoul Koulsoumi D, and Danwe Dieudonné: statistical analysis; Oummoul Koulsoumi D, and Danwe Dieudonné: manuscript drafting. Hamadou B, and Menanga A P: supervision.

## Conflict of interest

The authors declare no conflict of interest.

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