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Research Article

The Relationship Between the Decrease in Longitudinal Systolic Function and High Filling Pressures in The Hypertensive Patients

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Abstract:

Introduction: Heart failure with preserved LVEF (left ventricular ejection fraction) is an important cause of mortality and morbidity in hypertensive patients. A close correlation between the achievement of diastolic function and longitudinal systolic dysfunction could have several explanations, first the diastole is a dependent energy process, especially during its first phase, it also includes active systolic components during the iso volumetric relaxation phase.

The objective of this work is to determine the effect of diastolic function on the drop in GLS (global longitudinal strain) in hypertensive patients with preserved LVEF.

Materials and methods: This work is to perform in a series of 400 hypertensive patients (aged 25-75 years) an echo study full cardiographic, including the study of the systole-diastolic function, and the evaluation of the function by the longitudinal 2D strain.

Results: Of the 400 hypertensive patients, 356 patients (89%) had impaired diastolic function, of which 46 patients (13%) had high filling pressures.144 patients had a high LA(left atrial) volume, of which 46 patients had high filling pressures.

Of the 144 patients with high LA volume 118 patients (81.9%) had low GLS.

The mean of blood pressure was significantly higher in patients with low GLS.

There is a statistically very significant relationship between lower GLS, increased left atrium volume, and increased left ventricular filling pressures in hypertensive patients.

Conclusion: The decline in longitudinal index of function, despite preserved LVEF, correlates well with increased left atrial volume, filling pressures in hypertensive patients with LVH (left ventricular hypertrophy). The association between hypertension with LVH and the deterioration of asymptomatic diastolic function is well recognized.

Keywords: Hypertension, Filling Pressure, Left Ventricular Function, Strain

Introduction

LVEF-preserved heart failure is an important cause of mortality and morbidity in hypertensive patients [1]. A close correlation between the achievement of diastolic function and longitudinal systolic dysfunction. The progression of diastolic dysfunction is therefore accompanied by a deterioration of longitudinal systolic function, indicating that the two conditions are related to varying degrees, can realize a continuous spectrum of the course of the process of myocardial dysfunction [2, 3].The objective of this work is to study the correlation between the elevation of left ventricular filling pressures and the early installation of hypertensive heart disease, as well as the determination of the influence of impaired diastolic function.

Methods:

A cross-sectional analytical study was carried out in 400 hypertensive patients recruited from the outpatient cardiology consultation. All patients fulfilled the following criteria: age> 30 years blood pressure (BP) systolic > 140 mm Hg, BP diastolic > 90 mmHg, or both, or the notion of taking a treatment antihypertensive before inclusion. LV ejection fraction (LVEF) >55%, was determined using of Simpson's biplane method.

The non-inclusion criteria were: secondary hypertension; cardiomyopathy associated; moderate or severe valve disease; there evidence of active coronary artery disease; there atrial fibrillation or wearing a pacemaker cardiac.

The exclusion criteria were: patients with left ventricular dysfunction.

All participants have already been followed in ambulatory. The

recruitment period for the study was carried out between September 2020 and September 2022.
All patients gave informed consent formal and the study was approved by the committee ethics of the institution.

Clinical assessment

All demographic parameters (gender and age), anthropometric (weight, height and mass index (BMI)) and clinical (risk factors cardiovascular, duration and control of hypertension) were recorded, as well as routine medical treatment.
The severity of hypertension was assessed according to the European Society of Hypertension and lines guidelines of the European Society of Cardiology [4, 5].
Brachial BP was measured at the same time as echocardiographic examination using a sphygmomanometer after a rest period of 5 minutes in a seated position, and the average of two Consecutive reads were included for analysis.
The biological assessment consisted of making a lipid profile (total cholesterol, (LDL)-cholesterol, (HDL)- cholesterol and triglycerides), blood glucose and renal function, with calculation of the clearance of the creatinine according to the MDRD formula.
A 12-lead resting electrocardiogram (ECG) was performed (25 mm/s, 10 mm/mV).
LVH was diagnosed using the indices Sokolow-Lyon and Cornell.

Echocardiographic evaluation

All echocardiographic measurements were performed using an ultrasound scanner available in commerce (VIVID S6, General Electric Health care, Milwaukee, WI, USA) equipped with a second harmonic, 4.0MHz frequency. Analysis included two-dimensional examination, M-mode, a study coupled with Doppler (pulsed, continuous and color), and a study of myocardial deformities longitudinal (2D strain). Information patients' personal data have been integrated into echo computer, including name, age, weight, size and BP. All acquisitions have been performed by the same experienced operator. Three consecutive cardiac cycles were acquired at the end exhalation in left lateral decubitus, and connected to an ECG recorder, as recommended by the American Society of Echocardiography [6].
All standard measurements were obtained in parasternal major axis, minor axis and apical four, three and two cavities. The end-diastolic LV(left ventricular) diameter (Dd), end systole LV diameter (Ds), end-diastolic thickness of the ventricular septum (VST), and end-diastolic thickness of the LV posterior wall (PWT) allowed calculation of LV mass and relative LV wall thickness (RWT) as follows:
LV mass (g) = 0.8 × 1.04 × [(Dd + PWT + VST)3 − Dd3] + 0.6 - RWT = 2 × PWT/Dd
RWT was used to classify patients as follows: (1) RWT and LV mass index (LVMI) normal (normal geometry); (2) LWT increased, but normal LVMI (concentric remodelling); (3) increase in RWT and LVMI (hypertrophy concentric); or (4) normal RWT and increased LVMI (eccentric hypertrophy) [7].
LV mass was indexed to body surface area of patients, with the exception of obese subjects who were normalized by the height in meters to the power allometric of 2.7, which linearizes the relationships between LV mass and size [7,8]. LVMI greater than 115 g/m2 for men and 95 g/m2 for women defined LVH and subgroups of LV geometry: normal, concentric remodelling, concentric hypertrophy or hypertrophy eccentric, per ASE 7 guidelines.
In obese subjects, thresholds of 49 g/m2.7 in men and 45 g/m2.7 in women were considered [9, 10].
LV diastolic function was assessed by the Pulsed Doppler. The early peak diastolic velocity (E), maximum atrial systolic velocity (A), and the E/A ratio were assessed. Annular velocity mitral was recorded on the septal walls and lateral by tissue Doppler.
The early diastolic peak (E') at the septal level and lateral and the ratio (E / E') were calculated. The volumes have been determined. The left ventricular filling pressures (LVFP) were evaluated using the algorithm of the American Society of Echocardiography.
- Grade I diastolic dysfunction was defined as E' septal<8, E' lateral<10, volume of the LA <34 ml / m2, E / A <0.8, time of deceleration > 200 ms, and an E/E ratio '< 7.
- Grade II diastolic dysfunction was defined as E' septal <8, E' lateral <10, volume of LA<34 ml/m2, E/A between 0.8-1.5, time of deceleration 160-200 ms, and an average ratio E / E' between (8, 11).
- Grade III diastolic dysfunction was defined as E' septal <8, E' lateral <10, volume LA <34 ml/m2, E/A >2, deceleration time <160 ms, and an E/E' ratio > 13[11, 12].

Systolic lung pressure was calculated by the recording of the maximum speed of the tricuspid regurgitation. In patients in which no tricuspid regurgitation has been recorded, the pulmonary insufficiency flow was used, when present, to get an idea of the diastolic lung pressure.

Standard assessment of left atrium

LA volumes were calculated from apical four-chamber and two chamber views using the biplane Area-Length method[13]. Maximal and minimal LA volumes were measured just before mitral valve opening, and at mitral valve closure, respectively. The LA volume index was calculated in ml/m2 automatically by the machine
(Inputs: A1: Max. planimetered LA area in apical 4-chamber (A4C) view, A2: Max. planimetered LA area in apical 2-chamber (A2C) view, L: Length measured from back wall to line across mitral valve hinge points (cm), Weight (kg or Ib) and Height (cm or in)).
The following indices of LA function were calculated: Total LA stroke volume (LASV) could be obtained as the difference between maximal and minimal LA volumes. LA expansion index could be obtained as the ratio of total LASV to minimum LA volume ×100.

Two-dimensional deformation imaging by the speckle tracking

The technique has been used for systolic function longitudinal [14].
Apical sections of two, three and four cavities were acquired

using a frame rate high (70-100 frames / s). The image analysis was performed in a blind manner using a AFI-type package (Automatic function imaging).

Clicks and points based approach has been used to identify three anchor points (basal and apical) on which the software followed the boundaries of endocardium automatically for each of the three apical sections delimiting the endocardium of the LV, at the end systole, then transferred off-line to a workstation PC work using analysis software custom Echo PAC PC version 6.0.x (GE Healthcare, Fairfield, CT, USA). The LV was divided into17 segments, and automatic strain measurements segmental longitudinal systolic were performed in two, three and four cavities. There systolic function was assessed by measuring the peak of global systolic strain (GLS [%]).

Statistical analysis

The statistical analysis was divided into two parts. There first part focused on the study of the characteristics of the population while the second studied the risk factors for lowering the GLS. Comparisons of continuous variables expressed as mean values ± standard deviation (SD) were performed using ANOVA.

Data analysis was performed using the SPSS software (Graduate Pack for Windows, version20). A p-value <0.05 was considered as significant.

Results

The study included 400 hypertensive patients (mean age 62,3±8,7 years, 42% male) with preserved ejection fraction. 68% of whom had been diagnosed with HTN more than five years previously. None were in New York Heart Association functional class ≥II.

All patients were from Algeria.

BMI: body mass index, HTN: hypertension.

The basic characteristics of the population are summarized in Table 1.

Table1: General characteristics of the population

Age(years)	62.3±8.7	
Sex	**Men**	**Women**
	168(42%)	232(58%)
BMI(Kg/m²)		
Mean	29.7±3.2	
Normal	92(23%)	
Surcharge	180(45%)	
Obesity	128(32%)	
Waist size (cm)		
Normal	158(39.5%)	
High	242(60.5%)	
Type II Diabetes	170(42.5%)	
Renal failure	54(13.5%)	
Smoking	74(18.5%)	
Dyslipidémia	166(41.5%)	
Control of HTN		
Controlled	194(48.5%)	
No controlled	206(51.5%)	
Antihypertensive therapy		
Diuretics	48.5%	
Beta-blockers	12.5%	
Angiotensin II receptor blockers		48%
Calcium channel blockers	44%	
ACE inhibitors	18%	

The average of the blood pressure figures correlated to the LVFP was statistically higher in the subgroup of hypertensive patients with elevated filling pressures (table 2).

Table 2 : The mean of blood pressure figures correlated with LVFP

	SBP	DBP	*P*
Normal LVFP	144±17	76±12	*<0,0001*
High LVFP	165±20	85±13	*<0,0001*

LVFP: left ventricular filling pressures

3.2 Conventional echocardiography

The prevalence of left ventricular hypertrophy (LVH) was 56.8% in this population. Two-thirds of patients (66%) had a concentric hypertrophy, 17,5% concentric remodelling and only 12% have an eccentric hypertrophy. We found that that 71% of our patients had relative wall thickness (RWT)>0,42.

Alterations in diastolic function were detected in 89% (n=356), with grade I dysfunction in 69% (n=246) and grade II in 18% (n=64) and 13% (n=46) presented severe diastolic dysfunction with elevation of filling pressure.

An increase in left atrial volume was found in 36% of patients, and in all patients with high filling pressures.

Of the 46 patients with high filling pressures, 35 of them had diabetes, 38 patients had poor blood pressure control and 35 patients were obese.

All patients with high filling pressures had left ventricular concentric remodelling or hypertrophy.

Table 3 : Echocardiographics characteristics of the subgroup of study population.

-	**HBP without elevation of FP (n=354)**	**HBP with elevation of FP (n= 46)**	**P**
Ejection fraction (%)	61.3±6.2	60.9±6.0	0.63
Raccourcissment Fraction	34.5±6.6	34.9±5.8	0.45
LV indexed mass g/m2	109.6±24.8	116.05±35.1	**0.006**
RWT	0.44±0.07	0.46±0.08	**0.0001**
LV normal geometry	89(25%)	0(0%)	**<0.000**
Concentric Remodelling	67(19%)	13(28%)	**0.005**
Concentric Hypertrophy	134(38%)	33(71%)	**<0.0001**
Eccentric hypertrophy	67(19%)	0(0%)	**<0.000**
LA cm	38.5±5.6	39.6±5.8	0.25
LA volume ml/m2	15.5±6.0	18.8±8.1	**0.001**
E/A	0.76±0.2	0.85±0.5	0.25
E/E'	6.0±2.1	7.4±3.0	**0.001**
Mean GLS (%)	-18.4±2.9	-15.3±1.6	**<0.0001**

RWT : relative wall thickness

Of the 400 hypertensive patients, 46 patients had elevated filling pressures. Almost all of these patients (40 patients) had a low GLS. There is a statistically very significant relationship between the fall in GLS and the rise in left ventricular filling pressures in hypertensive patients.

OR: Odds ratio, IC95%: confidence interval, pb: significance level of the variable (Wald test).

Table 4 : GLS and filling pressures

	Nomal GLS n(%)	Pathological GLS n(%)	OR $_{(IC95\%)}$	P^b
Effectif	**218**	**182**		
Filling pressures				
Normal	212(97.2%)	142(78.02%)	1	
High	6(2.7%)	40(21.9%)	7.1(2.9-17.3)	**<0,0001**

Among the 46 hypertensive patients with high filling pressures, 30 patients (40.5%) had a GLS>-13%. There is a very significant relationship (p=0.001) between the elevation of the filling pressures and the degree of severity of the longitudinal systolic dysfunction of the left ventricle.

Table 5 : GLS figures and filling pressures

	Moderate longitudinal dysfunction n(%)	Several longitudinal dysfunction n(%)	OR (IC95%)	P^b
Effectif	**138**	**44**		
Filling pressures				
Normal	109(76.7%)	33(23.2%)	1	**0.001**
High	5(12.5%)	35(87.5%)	2.91(0.41-4.84)	

OR : *Odds ratio,* IC95%: intervalle de confiance, p^b : seuil de signification de la variable (test de Wald).

Discussion

Diastolic dysfunction with high PRVG is an important and independent predictor of cardiac mortality. This confirms the prognostic importance of its detection in heart failure patients with preserved LVEF [15].
Left ventricular diastolic dysfunction with high LVFP was found in 13% of the population.
Our results are in agreement with those of Lloyd Dinide et al in the SPHERE study where the prevalence of LV diastolic dysfunction was 18% [16].
The value of the e' and of the E/e' ratio was considered as a prognostic indicator in a study conducted in 116 hypertensive patients hospitalized for heart failure with normal LVEF [17, 18].
A study conducted on 600 patients in a research institute on hypertension showed a strong correlation between the degree of LVH and the severity of left ventricular diastolic dysfunction [19].
In our study, 100% of our patients with high FP have concentric-type LVH.
The dilation of the left atrium is usually found in arterial hypertension apart from any valvular involvement. This dilation is one of the prognostic markers and may reflect left ventricular diastolic dysfunction. It can be used as one of the cardiovascular morbidity and mortality factors [20].
In a study conducted on a cohort of 10,719 patients spread over two years and having evaluated
the prognostic role of LA volume in patients with high FP with preserved systolic function, LA volume (elevated in 30.7% of the population) was considered a powerful prognostic factor for mortality of any causes [21].
There was a very significant link between rising filling pressures and falling GLS; indeed, almost all our hypertensive patients with high filling pressures had a low GLS, also with a good correlation with the degree of severity of the longitudinal dysfunction.
The rise in filling pressures was, after logistic regression, recognized as the most powerful independent determinant of the fall in GLS in the hypertensive population.
Yuming Mu et al [22] demonstrated in a series of 75 hypertensive patients that the 2D strain could be useful for the detection of early changes in left ventricular diastolic function. This study also demonstrated the strong correlation between increased LA volume and increased filling pressures.
The SPHERE study [23] is a multicentre study carried out on a cohort of 1556 patients with grade II to III hypertension and aimed at determining the prevalence of LV diastolic dysfunction and its relationship with longitudinal function indices.
The results of this study show that longitudinal LV dysfunction was an independent determinant of diastolic LV dysfunction, assessed by combination of TDI tissue Doppler and LA volume. This large-scale study has thus made it possible to prove that the use of the speckle tracking technique makes it possible to better identify the relationships between anomalies of longitudinal shortening and diastolic dysfunction in patients suffering from arterial hypertension, thus making it possible to make a early detection of diastolic impairment.
These results, which confirm ours, are relevant since hypertensive patients with preserved LVEF according to conventional ultrasound measurements may have subclinical dysfunctions, which may represent a major determinant of symptoms and prognosis [24].
Overall, a linear relationship is established between the increase in left ventricular mass, diastolic dysfunction and longitudinal systolic dysfunction of the LV.

5. Limitations

One limitation of this study that we measured only the longitudinal global strain, but not the radial and circumferential measures. The survey of cases was conducted at 82% by the principal investigator and is good in 90%, limiting the misclassification.
Also, descriptive study in one time, however, has limitations that deserve to be considered when interpreting the results. This study should be completed by a monitoring over time of our population.

Conclusion

A systematic analysis of the longitudinal systolic function should be carried out in all hypertensive patients with LVH, with impaired diastolic function, diabetic subjects and hypertensive patients over the age of five, or imperfectly controlled by medical treatment.
The present observations provide evidence that improving metabolic control and reducing BP may coordinate and

synergistically inhibit the progression of diastolic heart failure.

Ethics Committee Approval:

The methodology for this study) were obtained from Ethics Committee of University of Algiers, Faculty of medicine.

Conflict of interest

None.

Acknowledgment

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