Original paper

Evaluation of Subclinical Systolic Dysfunction in Patient with Grade 1 Diastolic Dysfunction

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Abstract

Background: Recent epidemiological studies have demonstrated that nearly half of all patients with heart failure (HF) have preserved left ventricular ejection fraction (HFPEF). Thereby it is mandatory to include other hemodynamic indices in the traditional evaluation of the systolic function of the heart beside the EF.
Aim **of the study** was to assess the occurrence of subclinical systolic dysfunction in hypertensive patients with diastolic dysfunction referred for echocardiograph assessment of left ventricular function in a hospital.
Methods: 30 patients were recruited from the Echocardiography lab. The analysis of diastolic dysfunction was based on the E/A ratio using PW- Doppler echocardiogram. measurement of EF and SV by measuring end systolic and end diastolic dimensions of left ventricle by M-Mode guided 2D echocardiogram. Measurement of HR from ECG. calculation of SI. CO and CI were done.
Results & Discussion: The percentages of parameters which were found below normal levels are as follow: SV: 33.3% (10 out of 30 patients). SI : 40%(12 out of 30 patients). CO: 20%(6 out of 30 patients) and CI:53.3%(16 out of 30 patients).
Conclusion : EF is not enough in evaluation subclinical systolic impairment in HT patient , CI should be used in concomitant with EF in traditional evaluation of any patient with suspicion of HF.
Keywords: Diastolic dysfunction, EF,CI.

Introduction

Recent epidemiological studies have demonstrated that nearly half of all patients with heart failure (HF) have preserved left ventricular ejection fraction (HFPEF). Compared to those with reduced EF, patients with HFPEF are more likely to have hypertension and atrial fibrillation [1]. K. Hogg, et al in (2004) concluded that a substantial portion of patients with symptomatic HF has been reported to have relatively normal or preserved left ventricular ejection fraction [2].Thereby it is mandatory to include other hemodynamic indices in the traditional evaluation of the systolic function of the heart beside the EF.
These hemodynamic parameters like:

-Cardiac index (CI) Is the volume of blood pumped from the heart per minute divided by body surface area (BSA); CO is normalized according to a patient body size(L/min/m2) as it increases proportional to the individual BSA. The normal range of cardiac index in rest is 2.6 - 4.2 L/min per square meter [3]

One commonly used formula for BSA, is the Mosteller formula [4] : BSA (m^2) =√weight (Kg)*height (cm)/3600.
The index is usually calculated using the following formula:

$$CI = \frac{CO}{BSA} = \frac{SV * HR}{BSA}$$

Where CI=Cardiac index , BSA=Body surface area , SV=Stroke volume, HR=Heart rate , CO=Cardiac output
-stroke volume (SV) is the volume of blood pumped from one ventricle of the

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heart with each beat. SV is calculated using measurements of ventricle volumes from an echocardiogram and subtracting the volume of the blood in the ventricle at the end of a beat (called end-systolic volume) from the volume of blood just prior to the beat (called end-diastolic volume), $SV = EDV - ESV$, normal range of SV is 60-100 ml/beat [5] .

-Stroke Volume Index Similar to cardiac index, is a method of relating the stroke volume to the size of the person.

SI=SV/BSA, normal range of SI is 33-47 ml/beat/m^2 [6]

- EF represents the volumetric fraction of blood pumped out of the ventricle (heart)

$$E_f = \frac{SV}{EDV} = \frac{EDV - ESV}{EDV}$$

Normal range of EF is 55-70% [7] .

Traditionally, EF measurement is used to diagnose HF. The view that systolic function is entirely normal in subjects with clinically overt HF and normal EF has been challenged [8].

Diastolic heart failure is defined as a condition caused by increased resistance to the filling of one or both ventricles; this leads to symptoms of congestion from the inappropriate upward shift of the diastolic pressure-volume relation [9] . A more practical definition for use in clinical practice is: a condition that includes classic CHF findings and abnormal diastolic and normal systolic function at rest [10,11]. Diastolic failure appears when the ventricle can't be filled properly because it can't relax or because its wall is thick or rigid. This situation presents usually a concentric hypertrophy. In contrast, systolic heart failure has usually an eccentric hypertrophy [12] .

diastole can be divided into four phases: isovolumetric relaxation, caused by closure of the aortic valve to the mitral valve opening; early rapid ventricular filling located after the mitral valve opening(E); diastasis, a period of low flow during mid-diastole; and late rapid filling during atrial contraction(A) [13] . Broadly defined, isolated diastolic dysfunction is the impairment of isovolumetric ventricular relaxation and decreased compliance of the left ventricle [14] .Although diastolic heart failure is clinically and radiographically indistinguishable from systolic heart failure, normal ejection fraction and abnormal diastolic function in the presence of symptoms and signs of heart failure confirm diastolic heart failure [14] .

Echocardiography is the gold standard to diagnose diastolic dysfunction by using pulsed wave dopplar echocardiography [15] to measure the E/A ratio which is the ratio of peak early diastolic filling velocity to peak filling velocity of atrial contraction in the mitral flow velocity. The late phase is dependent upon atrial contraction and therefore is absent in atrial fibrillation [16]. Normal values are between 0.75 and 1.5. Normal E is 0.6 to 0.9 m/sec and normal A is 0.3 to 0.5 m/sec. There are four grades of diastolic dysfunction but only patients of Grade I (impaired relaxation) were included in this study, so Grade I diastolic dysfunction means : The E wave velocity is reduced resulting in E/A reversal (ratio < 1.0). The left atrial pressures are normal. The deceleration time of the E wave is prolonged measuring > 200 ms. Patients with Grade II (pseudonormal) or Grade III (reversible restrictive) or Grade IV (fixed restrictive) were not included in the study.

Patients and methods

Patients

This retrospective study (cross sectional study) was conducted in the echocardiography unit at Shaheed AL-Mehrab center in Hilla city. This study involved 30 consecutive hypertensive patients who scheduled to undergo echocardiography for cardiac assessment. These patients with mean age ± SD of (61±1.2 years). Their signed consent had been taken.

Apparatus

1-Echocardiography with Doppler facility (Phillips-Japan).
2-Electrocardiography: as routine investigation to every patient consult the center for cardiac assessment.

Methods

Anthropometric data for patients included in the study are shown in table 1.The following parameters were measured for every patients involved in this study:
-Measurement of EF by M-Mode of the left ventricle: in left parasternal long axis view the curser applied through the center of the left ventricle at papillary muscle level (just distal to the mitral valve leaflets tips), then by M-Mode measurement of systolic and diastolic left ventricular dimensions to get EF , by the same way measurement of stroke volume.

Diastolic dysfunction were evaluated in apical 4 chamber view, using PW, with sample volume at the tip of the mitral leaflets to measures E/A ratio [17] .only grade1 diastolic dysfunction involved in this study.
-Heart rate (HR) were measured from ECG : as paper moves 1500 small division in a minute, so to measure heart rate, the number of small square between R-R interval is counted, 1500 divided by this number gives the heart rate [18,19].
-CO : were calculated from equation : CO= SV*HR [20] . Stroke volume and CO divided by BSA to get SI and CI.

Table 1.Anthropometric data for patients included in the study:

Anthropometric data	mean±SD	range
Age (yrs)	64 ±1.2	55-70
Weight Kg	83.73±13.17	60-120
Height-cm	169.53±7.34	165-182
BSA-m^2	2.08±0.4	1.8-3.4

Statistical analysis: All values were expressed as mean ± SD. The percentages of abnormal results for SV, SI, CO and CI were calculated in accordance of normal EF.

Results

All the patients that involved in this study were with grade1 diastolic dysfunction and with normal EF. The values regarding these parameters were illustrated in table-2.

Table 2. Parameters that were measured in this study :

parameter	Mean ±SD	Range
EF%	66.33±8.21	55-80
SV ml	74.74±26.5	38-111
SI ml/beat/m^2	36.53±13.64	19-58
HR beat/min	77±10.56	60-88
CO L/min	6.268±2.58	2.81-12.099
CI L/min/m^2	2.86±1.37	1.2-6.3

The percentages of parameters which were found below normal levels are as follow: SV: 33.3% (10 out of 30 patients). SI:40%(12 out of 30 patients). CO: 20%(6 out of 30 patients) and CI:53.3% (16 out of 30 patients). Figure 1

Discussion

Hypertension is the major cause of congestive cardiac failure all over the world. It is under diagnosed and achievement of optimal therapy is difficult and costly. Diastolic dysfunction is an early poor prognostic factor in hypertension and is a reversible condition [17] . Early detection of systolic impairment is necessary to avoid cardiac complications, traditional work in echocardiography lab is measurement of EF to assess the systolic function, but several studies show that sometimes there are systolic impairment in spite of normal EF. In fact a reduced LV systolic function, measured by TDI in the longitudinal direction, could be present in patients with heart failure and normal ejection fraction when measured by TDI technique [21,22] . It is possible, therefore, that even in the setting of a normal LV ejection fraction, an increase in arterial stiffness may be associated with an initial, subclinical reduction in the longitudinal LV systolic function.

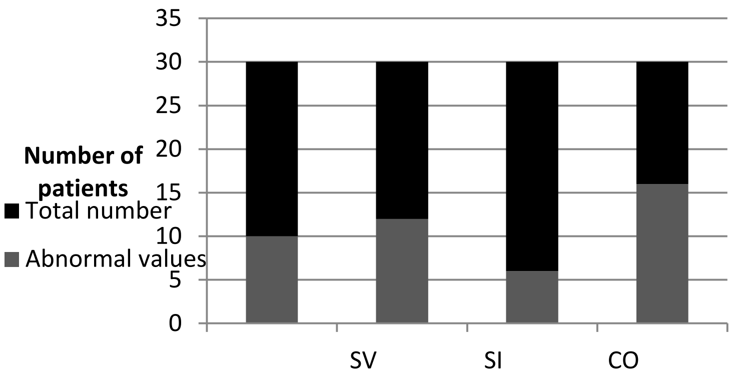

Figure 1: hemodynamic parameters that were measured in this study and their abnormal values :SV-stroke volume, SI-stroke index, CO-cardiac output, CI-cardiac index

Tsutsui, et al in (2010)[1] mentioned that hypertensive heart disease was more common in HFPEF and they founded that HFPEF have similar morbidity and mortality to those with reduced EF. Therefore, HFPEF does not readily mean "good" prognosis. Given the high risk of adverse clinical events and the lack of a sufficient evidence to guide the treatment, effective management strategies need to be established for HFPEF. Patients with HFPEF are older and more likely to have hypertension. Higher prevalence of HFPEF in elderly patients most likely reflects the effects of aging on myocardial structure . Páez-Rubio, et al in (2013) [23] suggested that heart failure with preserved and reduced ejection fraction could be distinct pathophysiological entities, at least in elderly patients The few previous studies that investigated this topic showed conflicting results [24, 25] . Russo, et al in (2011) [26] found that an increased arterial wave reflection was associated with subclinical reduction in LV systolic function assessed by novel TDI techniques with normal LVEF. In this study reduction in SV, SI, CO and CI in spite of normal EF could be explained that Patients with hypertension usually present with concentric remodeling (increased relative wall thickness despite normal LV mass) or concentric LV hypertrophy (an increase in both relative wall thickness and LV mass), but have a normal-sized LV chamber and normal EF, even in the presence of a reduced longitudinal systolic function [27]. CO had the lower percentage as it depend on SV and HR . SI and CI had the highest percentage because these indices were normalized according to body size, so it is better to measure CI beside EF in traditional work in assessing systolic function of the heart, this finding is supported by (Narahara and Blettel, 1983) [28] who concluded that unlike left ventricular ejection fraction (LVEF), CI offers a more precise estimate for the pumping action of the heart; it does not change with increase of heart rate and concomitant decrease of stroke volume, when pacing a normal size heart[28] , beside that Tribouilloy C in 2008 [29] reached a conclusion that Heart failure with preserved EF had a poor prognosis, comparable with that of HF with reduced EF, with a 5 year survival rate after a first episode of 43% and a high excess mortality compared with the general population.

Conclusion

EF is not enough in evaluation subclinical systolic impairment in HT patient. CI offers a more reliable estimate for pumping action of the heart, thereby, CI should be used in concomitant with EF in traditional evaluation of any patient with suspicion of HF

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Abbreviations

BSA-body surface area.CI-cardiac index. CO-cardiac output . EDV-end diastolic volume. EF-ejection fraction. ESV-end systolic volume. HF- heart failure. HFPEF- heart failure with preserved ejection fraction. HR-heart rate. LVEF-left ventricular ejection fraction.

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