RESEARCH PAPER

The effect of optimization of the heart rate in patients with dilated cardiomyopathy on left ventricular ejection fraction and global longitudinal strain

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Abstract

Background: Dilated cardiomyopathy (DCMP) is one of the disabling diseases all over the world including Iraq, and especially Basrah. It affects different age groups and both sexes.

Aim: to see the effect of optimization of heart rate on left ventricular ejection fraction and average global longitudinal strain.

Methodology and the Results: 33 patients with dilated cardiomyopathy (DCMP) are enrolled in this study from February 2019 to May 2021, their mean age was 39.6 year, 51.52% were male and female constitute 48.48%, the mean heart rate of those patients at the first visits was 102 beat per minute, the mean of their left ventricular ejection fraction (LVEF) at that time was 31%and the mean of their average global longitudinal (GLS) was -7%. That patient was treated by ant failure treatment with optimization of their heart rate, after 2 months of treatment their mean heart rate was significantly decrease to 76 BPM (P value < 0.001), however in spite of improvement in the functional capacity there was no significant correlation between the optimization of the heart rate and the LVEF (P value 0.317), on the other hand there was significant correlation in the average GLS after optimization of the heart rate (P value <0.006).

Conclusion: optimization of the heart rate associated with improvement in the functional capacity and GLS. GLS estimation is better than LVEF estimation in the assessment of LV function.

Key words: Dilated cardiomyopathy, entricular ejection fraction, global longitudinal strain

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Introduction

Dilated cardiomyopathy (DCMP) is one of the disabling diseases all over the world including Iraq, and especially Basrah.[1] It affects different age groups and both sexes. Patient with DCMP presented with different grades of shortness of breath with progressive decrease in cardiopulmonary functional status.[2] Clinically the patient had resting tachycardia with variable types of tachyarrhythmias like atrial fibrillation, flutter, ventricular tachycardia as well as atrial and ventricular premature complexes.[3] These changes in cardiac rhythm carry increased risk of mortality and morbidity like stroke and rapid worse progression in the left ventricular (LV) function.[4] Raised jugular venous pressure is one of the physical signs of heart failure indicating derangement in hemodynamics of the right side of the heart, fine basal crepitation with pedal edema are other physical signs.[5] 2-dimensional echocardiography is essential in the diagnosis of DCMP; in which there is global hypokinesia with increase in the end diastolic and systolic volume (LVEDV and LVESV) of the left ventricle with subsequent dilatation of left atrium and this might associate with dilatation of the right side of the heart. These chamber dilatations associated with

progressive decrease in the left ventricular ejection fraction (LVEF), stroke volume and cardiac output. As a result of dilatation of the annuli of the valves, functional valvular incompetence developed like mitral, aortic, pulmonary, and tricuspid regurgitation.[6] Modification of lifestyle with medical treatment play a major role in the management of DCMP to relieve the symptoms of the patient and to decelerate the progression of the disease. The patient is instructed to estimate the number of steps that he can walk in 10 minutes daily, to assess the response to the medical treatment and improvement in the functional capacity.[7] Another objective method for assessment progression of the disease and efficacy of the medical treatment is by using echocardiography. LVEF is one of these methods, LVEF is estimated by using the following equation:

($LVEF = \frac{\text{LVEDV}-\text{LVESV}}{\text{LVEDV}}$ multiplied by100).

This LVEF gives good idea about the global function of the left ventricle. LVEF of <50% is considered abnormal and it can be estimated by M-mode method and Simpson's method. Now, by the development of the software, most of the machines can estimate it by auto calculation of LVEF.[8] The development of speckle-tracking echocardiography (STE) helps to estimate the global longitudinal strain (GLS) which is a good diagnostic and prognostic parameter of LV dysfunction even in subclinical cases. This technique is based on tracking the movement of speckles generated by interaction of ultrasound waves and myocardium. By this method we can estimate the differences in the length of myocardial fibrils during systole and diastole. By STE, strain and strain rate can be calculated to give good information about the LV function.[9] Optimization of heart rate by using beta blockers causes good improvement in the functional capacity in most of the patients but this is not reflected by dramatic changes in the LVEF making the patient worried about this point.[10] In this study we compare the changes in LVEF and GLS after optimization of the heart rate and we try to find which is the best objective method for follow up of a patient with DCMP.

Methodology

This is an analytical study conducted at Basrah, Iraq in private clinic from February 2019 to May 2021. In this study, 33 patients with dilated cardiomyopathy were enrolled. After taking good history to assess the functional capacity of the patients with careful clinical examination, thyrotoxicosis was excluded by measuring free T3, free T4 and TSH. the heart rate was estimated by analysis of the ECG. Echocardiography was done for the patient by using Vivid E 90 and Vivid E95. Echocardiography was used to measure the left ventricular internal dimension in diastole (LVIDd), left ventricular internal dimension in systole (LVIDs). Left ventricular ejection fraction was estimated by using Simpson's method. Average global longitudinal strain (GLS) is also estimated in every patient. The patients were kept on full antifailure treatment using loop diuretic, aldosterone antagonist, beta blocker with or without angiotensin converting enzyme inhibitor. After 3 months of this medical management, the patients were assessed again by estimating the improvement in the functional capacity, all the above echo parameters are measured again using same echo machine and by the same operator. Analysis of the data was done by using SPSS version 23.

Results

Thirty-three patients enrolled in this study which was conducted during the outbreak of Covid 19, their age ranges from 30 to 47 years old with the mean age 39.60. seventeen of the patients (51.52%) were males, while females constitute 16 patients (48.48%). (Table-1), shows the characteristics of the echo findings at the first visit. In this table we see the patients had mean LVEF equal to 32%, with the mean of average GLS equal to -7 %, the mean of their heart rate was 102 BPM.

Table 1. Echo findings of the patients at the first visit

	No. of the patient	%
LVIDs1 {mean = 44.66 mm}		
40-44 mm	16	48.48
45-50 mm	17	51.51
Total	33	100
LVIDd1 {mean = 61.58 mm}		
≤ 50 mm	1	3.03
51-60 mm	12	36.36
61-70 mm	19	57.57
≥ 70	1	3.03
Total	33	100
LVEF1 {mean = 32.36%}		
20-29%	5	15.15
30-39%	24	72.7
≥ 40%	4	12.1
Average GLS1 {mean = -7.13%}		
≤ -5%	5	15.15
-5% to -10%	28	84.84
Heart rate {mean = 102 beat per minute}		
90-100 beat per minute	22	66.66
>100 beat per minute	11	33.33

(Table-2), describes the characteristics of the echo findings after 3 months of antifailure treatment. The table reveals the changes in echo parameters after decreasing the heart rate by using beta blockers. In this table, the mean of the heart rate decreases to 76 BPM, and the mean of the average GLS changes to -12%, and the mean of LVEF is 36%.

Table 2. Echo findings of the patients on the second visit

	No. of the patient	%
LVIDs2 {mean = 43.09 mm}		
40-44 mm	17	51.51
45-50 mm	16	48.48
Total	33	100
LVIDd2 {mean = 60.24 mm}		
≤ 50 mm	1	3.03
51-60 mm	22	66.66
61-70 mm	10	30. 3
total	33	100
LVEF2 {mean = 35.93%}		
20-29%	0	0
30-39%	27	81.81
≥ 40%	6	18.18
Average GLS2 {mean = -12.18%}		
≤ -10%	2	6.06
> -10%	31	93.93
Heart rate {mean = 75.51 beat per minute}		
60-69	6	18.18
70-79	12	36.36
80-89	15	45.45

(Table-3), shows the differences in the echo parameters and heart rate in 2 visits. this table shows significant differences in the echocardiographic parameters and heart rate between the visits.

Table 3. The differences in the means of the heart rate and the mean of echo parameters in 2 visits

The mean of the parameters	95% confidence interval	T-value	Degrees of freedom	One-sided p-value	Two-sided p-value
LVEF1-LVEF2	-0.40224	-2.425	32	0.011	0.021
LVIDs1-LVIDs2	1.74957	4.594	32	< 0.001	< 0.001
LVIDd1-LVIDd2	3.3103	2.901	32	0.003	0.007
HR1-HR2	28.73202	30.611	32	< 0.001	< 0.001
Average GLS1-average GLS2	-4.67596	-28.027	32	< 0.001	< 0.001

Table-4, shows the effect of the heart rate on the LVEF, chambers size, and average GLS. The table unfolds that when the heart rate is decreased there is no significant changes in the LVEF (P-value equal to 0.317), while there is significant change in the average GLS when the heart rate is decreased (P value equal to 0.006). The changes in the heart rate significantly affect the systolic internal dimension of the left ventricle with no significant changes in the dimension during diastole (P- value equal to 0.009, and 0.316, respectively)

Table 4. The Correlation of the optimization of the heart rate with the echocardiographic parameters

Mean of the heart rate and the mean of echo parameters	No.	correlation	One-sided p-value	Two-sided p-value
HR1 & LVEF1	33	-0.447	0.005	0.009
HR1 & average GLS1	33	-0.640	<0.001	<0.001
HR1 & LVIDs1	33	0.431	0.006	0.012
HR1 & LVIDd1	33	0.026	0.443	0.886
HR2 & LVEF2	33	0.086	0.317	0.634
HR2 & average GLS2	33	0.430	0.006	0.013
HR2 & LVIDs2	33	0.406	0.009	0.019
HR2 & LVIDd2	33	0.086	0.316	0.632

Discussion

Follow-up of the LV function in patients with LV dysfunction after optimization of the heart rate deserves discussion. Echocardiographic examination is an essential tool for follow-up of patients with heart failure, but it is a crucial tool because a substantial proportion of HF patients may show dynamic changes in LVEF over time, especially those with an ischemic heart disease. Measurement of LVEF had many limitations, such as variability between different imaging techniques, poor reproducibility, and moderate correlation with functional capacity.[11-13] The current study reveals that decrement of the heart rate in patients with LV dysfunction after 3 months of treatment was not associated with a significant increase in the LVEF. However, there is a significant improvement in the average GLS

over these 3 months. As seen in the table there is a nonsignificant correlation between the optimization of the heart rate with the LVEF (p - value 0.317). At the same time there is a highly significant correlation between the optimization of the heart rate with the average GLS (p-value 0.006). In this study 2 important points require explanations. First the role of optimization of heart rate in the improvement of the symptoms of the patient and improvement of functional capacity, and which is the best measure that document this improvement in the functional capacity. It was reported that cardiovascular death increased by 14%with an increase of 10 bpm in heart rate.[14] This correlation is most apparent in sudden death complicating myocardial infarction. However, heart rate and mortality in patients with heart failure are not straightforward as observed in coronary artery disease.[15] This is because of the complicated features of death from heart failure. In heart failure there is a mixture of sudden death and death from pump failure; in that sudden cardiac death is not proportional with the functional class while pump failure is proportionally increased with the progression of ventricular dysfunction.[16] The correlation between heart rate and mortality in myocardial infarction is independent of age, functional capacity, blood pressure, daily physical activity and body mass index. The harmful effect of an increase in the heart rate, on the heart, might be related to abnormal calcium handling, down-regulation of myocardial β1 receptor, depletion of myocardial energy stores, and chronic ischemia like stunning or hibernation.[17] In a meta-analysis of more than 35 studies, there is a strong correlation between the reduction of heart rate and cardiovascular mortality.[18] Hazard regression model analysis showed that a heart rate reduction of 5 BPM could provide a 14% reduction in mortality in β-blocker treatment.[19] This correlation between heart rate and cardiovascular mortality is not only related to β-blocker, in the SHIFT trial Ivabradine decreased heart rate by as much as 10.9 BPM with a significant reduction in primary endpoint by 18%.[20] Some studies showed that atrial pacing at a rate of 80 BPM for 14 months deteriorated LV function compared with pacing at 60 BPM.[21] It can be concluded that heart rate reduction by β-blockers or other means is critically important in the improvement of the clinical outcome of heart failure patients. The second point elicited in the current study is the proper way for assessment of LV function. LVEF is a routine and cornerstone echocardiographic parameter used for the evaluation of LV function to guide the management of different patients, which is proved to be highly correlated with their prognosis. However, there are some limitations in the estimation of LVEF by echocardiography, and it is associated with inter-observer variability. These limitations depend on image quality and the ability to visualize the endocardial borders. GLS is also used in the assessment of LV function by interpreting the percentage change in the length of myocardial fibrils. It has a lot of benefits in variable clinical conditions like evaluation and follow-up of coronary artery disease, cardiomyopathy, valvular heart diseases as well as cardiac toxicity due to chemotherapy. Although poor image quality would also affect the accuracy of GLS measurements because of the suboptimal endocardial border tracking, the GLS has better inter- and intra-observer reproducibility in post hoc analysis compared to LVEF. In the present study, the improvement of the functional capacity in correlation with a decrease in the heart rate within 3 months was associated with significant improvement in the

GLS in comprise with no significant changes in the LVEF. This study is consistent with the previous studies that reveal that GLS is more reproducible than LVEF estimation. so GLS estimation should be a routine measure that is most used for the assessment of LV function.

Conclusion and recommendations, the optimization of the heart rate is associated with the improvement in functional capacity and GLS. GLS estimation is better than LVEF estimation in the assessment of LV function. GLS can be a routine examination for follow-up of patients with heart failure.

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تأثير ضبط الدرجة المثلى لمعدل ضربات القلب على الكسر القذفي ومعدل الشد الطولي العام للبطين الايسر لدى مرضى اعتلال العضلة القلبية

الخلفية: اعتلال عضلة القلب التوسعي (DCMP) هو أحد الأمراض المسببة للإعاقة في جميع أنحاء العالم بما في ذلك العراق، وخاصة البصرة. يؤثر على مختلف الفئات العمرية وكلا الجنسين.

الهدف: لحساب مدى تأثير ضبط الدرجة المثلى لمعدل ضربات القلب على الكسر القذفي ومعدل الشد الطولي للبطين الايسر.

الطريقة والنتائج: تم ادراج ٣٣ مريض مصاب باعتلال العضلة القلبية في هذه الدراسة التي أجريت في محافظة البصرة للفترة من شهر شباط ٢٠١٩لغاية مايس ٢٠٢١ وكان معدل اعمار المرضى ٣٩،٦ سنة نسبة الذكور كانت ٥١،٥١٪ ونسبة الاناث ٤٨،٤٨٪.. معدل ضربات القلب في الزيارة الأولى كان ١٠٢ ضربة بالدقيقة و معدل الكسر القذفي للبطين الايسر في الزيارة الأولى كان ٣١٪، وكان معدل الشد الطولي للبطين الايسر -٧٪. اعطي جميع المرضى العقاقير الخاصة بعلاج عجز القلب لمدة شهرين فكان معدل ضربات القلب بعد شهرين قد انخفض الى ٧٦ضربة بالدقيقة. هذا التغيير في معدل ضربات القلب كان مصاحبا لشعور المريض بتحسن في السعة الوظيفية، ولكن لم يكن هنالك تغيير مهم في الكسر القذفي للبطين الايسر في حين لوحظ تغير مهم في معدل الشد الطولي للبطين الايسر.

الاستنتاجات: ان تقليل معدل ضربات القلب لمرضى الاعتلال يعكس تحسن واضح بحالة المريض المصاب باعتلال العضلة القلبية وان اعتماد حساب معدل الشد الطولي لمرضى الاعتلال بعد شهرين من العلاج أفضل من حساب الكسر القذفي للبطين الايسر.

الكلمات المفتاحية: اعتلال عضلة القلب التوسعي، جزء القذف الثلاثي، الإجهاد الطولي العالمي