Direct detection of Left Ventricular Diastolic Dysfunction by Phase image analysis in Gated Thallium SPECT Scan

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Abstract

Aim: *The evaluation and differentiation of Left Ventricular Diastolic Dysfunction has a vital role in the management of heart failure patients. Currently the diastolic dysfunction is inferred from the E and A wave changes occurring in m-mode echocardiographic changes at the mitral orifice mostly. In the gated myocardial perfusion imaging from the time volume curve the Peak Flow Rate and Time to Peak Flow rate are derived and assessed for the presence and extent of diastolic dysfunction. All these parameters represent the changes that are occurring due to the underlying diastolic dysfunction in the left ventricular muscle mass. For the first time this study aims to highlight the diagnosis of Left Ventricular Diastolic Dysfunction by the visual Phase image analysis in Gated Thallium SPECT Scan. The presence of in-homogenous, irregular and insufficient tracer accumulation in the Diastolic phase images with the normal and homogenous tracer distribution in the Systolic Phase images is proposed to indicate the diastolic dysfunction. It also thrives to quantitate the changes observed by calculating the S/D ratio by dividing the Systolic Counts by the diastolic counts obtained from the raw phase images. It is correlated with echocardiographic stages of the Diastolic Dysfunction.*

Materials and Methods: *This study consists of 75 Males in the age group of 28 to 63 years with mean age of 47.9 +/- 7.8 years and 25 Females in the age range of 32 to 55 years with mean age of 49 +/- 6.8 years. After exercising the patients on a bicycle ergometer using Bruce Protocol 2 mCi of Thallum-201 was injected intravenously Gated SPECT MPI were acquired using Siemens Dual Head E-Cam Gamma Camera. The analysis was done using GATED SPECT PERFUSION ANALYSIS Protocol. The S/D ratio was calculated using the region ratio count protocol in the ICON software.*

Results: *The discordance between the Diastolic and systolic images were found in 98/100 (98%)-Image1,2. The Echocardiographic evidence of Diastolic dysfunction as classified into Grade II and grade III using E / A ratio analysis was found in 87/100 (87%). The diabetes was seen in 16/100 (16%) and Hypertension was encountered in 63/100 (63%). The S/D ratio was 1.27 +/- 0.32 in Grade IILVDD and 1.68 +/- 0.03 Grade III LVDD.*

Conclusion: *In conclusion for the first time the utility of direct visual individual phase image analysis in the detection of Left Ventricular Diastolic Dysfunction is highlighted. The Scintimetric Characterization of the same with the help of S/D ratio shown it to be different between stage II and stage III LVDD.*

Keywords*: Gated Thallium SPECT, Left Ventricular Diastolic Dysfunction, echocardiography, Scintimetric evaluation, S/D Ratio.*

Introduction

The diastolic function of the left ventricle has a vital role in the preservation and efficacy of the left ventricular systolic function. Hence, the evaluation of left Ventricular Diastolic function is of much concern in the diagnosis and management of the left heart failure. Routinely it is evaluated by the M-mode echocardiography at the mitral valve orifice from the tracing E / A ratio is calculated. The E / A ratio of < 0.8 is considered to represent Stage I, > 1.4 in Stage II and > 1.8 in Stage III left ventricular Diastolic dysfunction [1,2]. Further refining of these parameters by introducing the Color Doppler echocardiography and tissue characterization methods also have been described [3].The advent of ECG- Gated SPECT studies has enabled us to have greater insights into its evaluation. The calculation of Ejection Fraction and visual analysis of Regional Wall Motion Abnormalities by the Gated SPECT Myocardial Perfusion Studies are well known and most utilized. However, the portal of analyzing and extracting useful information from the Phase image analysis of diastolic and systolic phases of the cardiac cycle remains unexplored. After Morgan and Mannting [4] described the utility of Gated SPECT Myocardial Perfusion Imaging in 1993 it was Raymond Taillefer [5] et al described the utility of Diastolic Image analysis in the early detection of C.A.D in women as against Summed image analysis in 1999. Siemens has developed a GATED SPECT PERUFSION PROCESSING protocol based on the work of Depuey et al [6] which includes separate image analysis in Diastole and Systole, Ejection fraction calculation and Regional Wall Thickness assessment. Utilising Phase image analysis in the Gated SPECT Perfusion processing the incidence of In-homogenous, Irregular and Insufficient Tracer distribution in the diastolic images in the presence of Normal homogenous, regular and sufficient uniform tracer distribution in the Systolic summed images is inferred to indicate the presence of diastolic dysfunction. Its association with the echocardiographic diastolic dysfunction markers particularly E/A ratio and Diabetes Mellitus & Hypertension is also highlighted in our presentation in SNMICON [7]. The good correlation between the Peak Flow rate and S/D ratio calculated using the Time Volume curves obtained from the ECG- gated SPECT and the E / A ratio had been documented [8]. The normal values of the diastolic dysfunction parameters like Peak Flow Rate and Time To Peak Flow have been reported in the assessment of diastolic Function Using 16Frame 99mTc-Sestamibi Gated Myocardial Perfusion SPECT with total agreement between the QGSPECT and the Echocardiographic assessment [9]. In their experience with 16-gated Myocardial Perfusion SPECT assessment of Diastolic Heart Function RD Lele et.al have reported that diastolic dysfunction was diagnosed in 92 / 121 (76%) and only 53/121 (43%) by echocardiographic E / A ratio analysis [10].

Aims

This prospective study aims to highlight the (i) utility of summed image analysis of the Diastolic and Systolic phases of the Cardiac cycle in the visual diagnosis of the Left Ventricular diastolic dysfunction and (ii) to quantitatively differentiate between the different echocardiographic stages of the LVDD as reported in the echocardiography report.

Materials and Method

The Left ventricular Diastolic Dysfunction evaluation study consists of 35 males in the age range of 31 to 67 years with mean age of 51.9 +/- 7.4 years and 12 females in the age range of 31 to 55 years with mean age of 45.9 + / - 6.6 years. After exercise the patients on a Treadmill using Bruce Protocol 2 mCi of Thallum-201 was injected intravenously Gated SPECT MPI were acquired using Siemens Dual Head E-Cam Gamma Camera. The images were analysed using the ICON Software GATED

SPECT PERFUSION ANALYSIS Protocol. The presence of in-homogenous, irregular and insufficient tracer distribution in the diastolic phase images as comparedto the normal Systolic phase images denote the diastolic dysfunction changes in the left ventricualr muscle tissue as shown in Fig.1
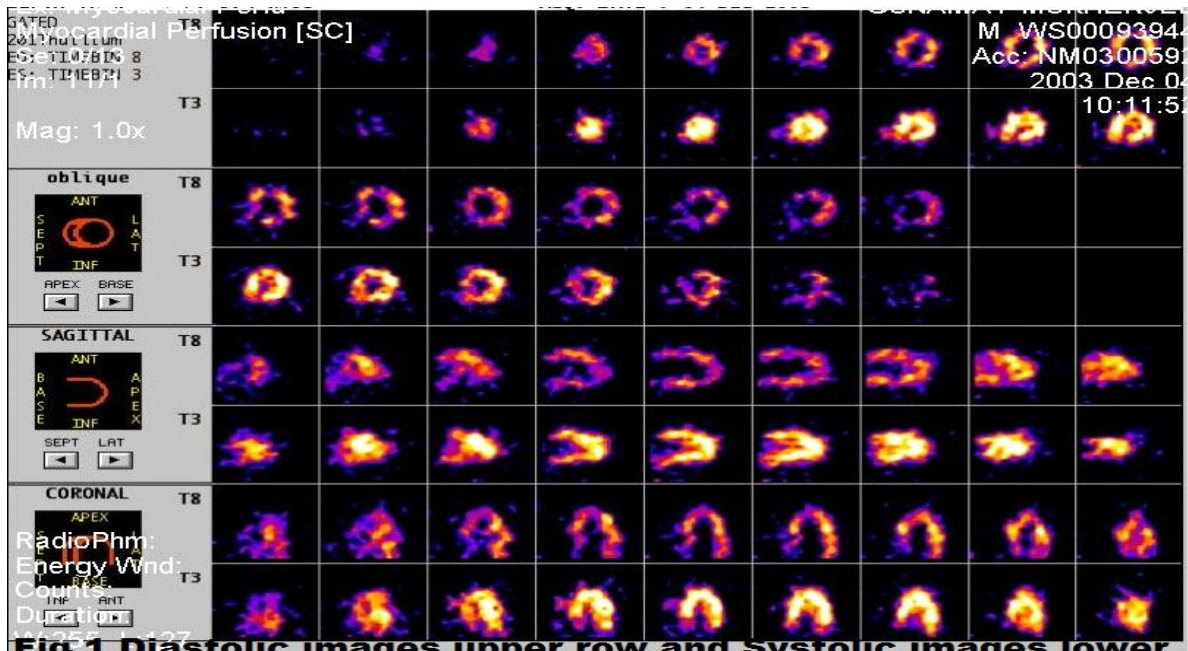

Fig.1 Diastolic images upper row and Systolic images lower row in 3 different views

The upper row diastolic phase images in different views show consistently decreased, in-homogeneous, insufficient and irregular tracer distribution indicative of perfusion deficiency in them.The lower row systolic phase images show normal and uniform tracer distribution. This finding of discordance between the diastolic and systolic phase images isattributed to direct changes occurring in the left ventricular muscle mass due to diastolic dysfunction. These images are subjected to left ventricular ejection fraction and Bull's eye map analysis of the end diastolic perfusion, end systolic perfusion and wall thickening estimation as shown in Fig.2.
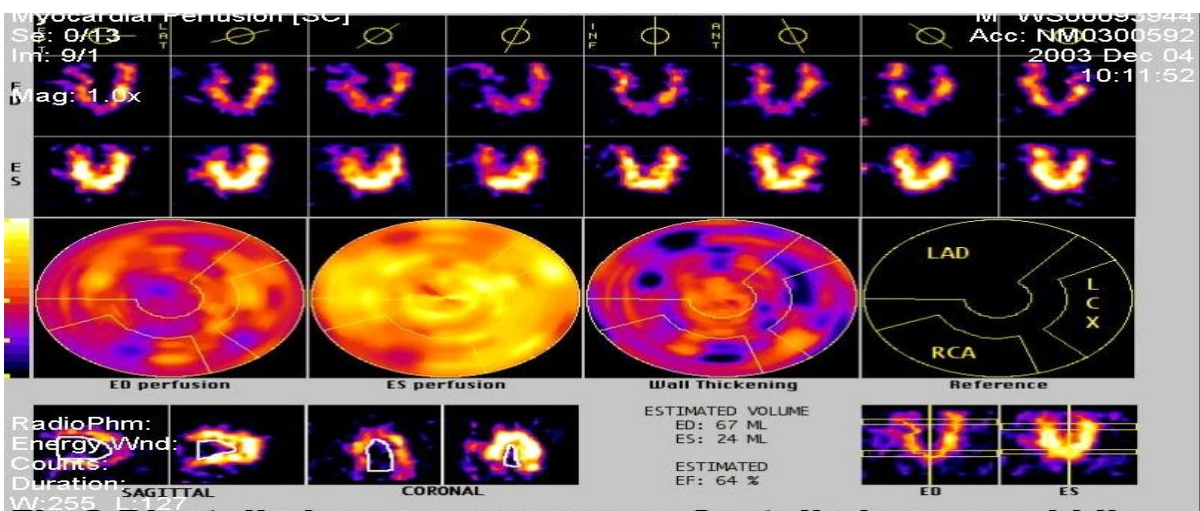

Fig.2 Diastolic images -upper row, Systolic images middle row, Bull's eye maps third row

The upper and lower row images represent the diastolic and systolic phase images respectively. The diastolic phase ED perfusion bull's eye map shows moderate to severe affliction as per the colour scale and the systolic phase ES perfusion bull's eye map shows normal state as per the colour scale. The calculated left ventricular ejection from the derived end diastolic ED and end systolic ES volumes is in the normal range.

The findings are noted down. The echocardiographic grading of the left ventricular diastolic dysfunction is also tabulated along with the above findings from the case records.The image data sets of the diastolic and systolic images in the S.A, H.L.A & V.L.A views were saved separately. Then the Ventricular wall outline is outlined by drawing their outer and inner margins in the representative Diastolic and Systolic phase images and the counts in the region of interest were calculated using the region ratio count protocol in the ICON software Fig. 3.
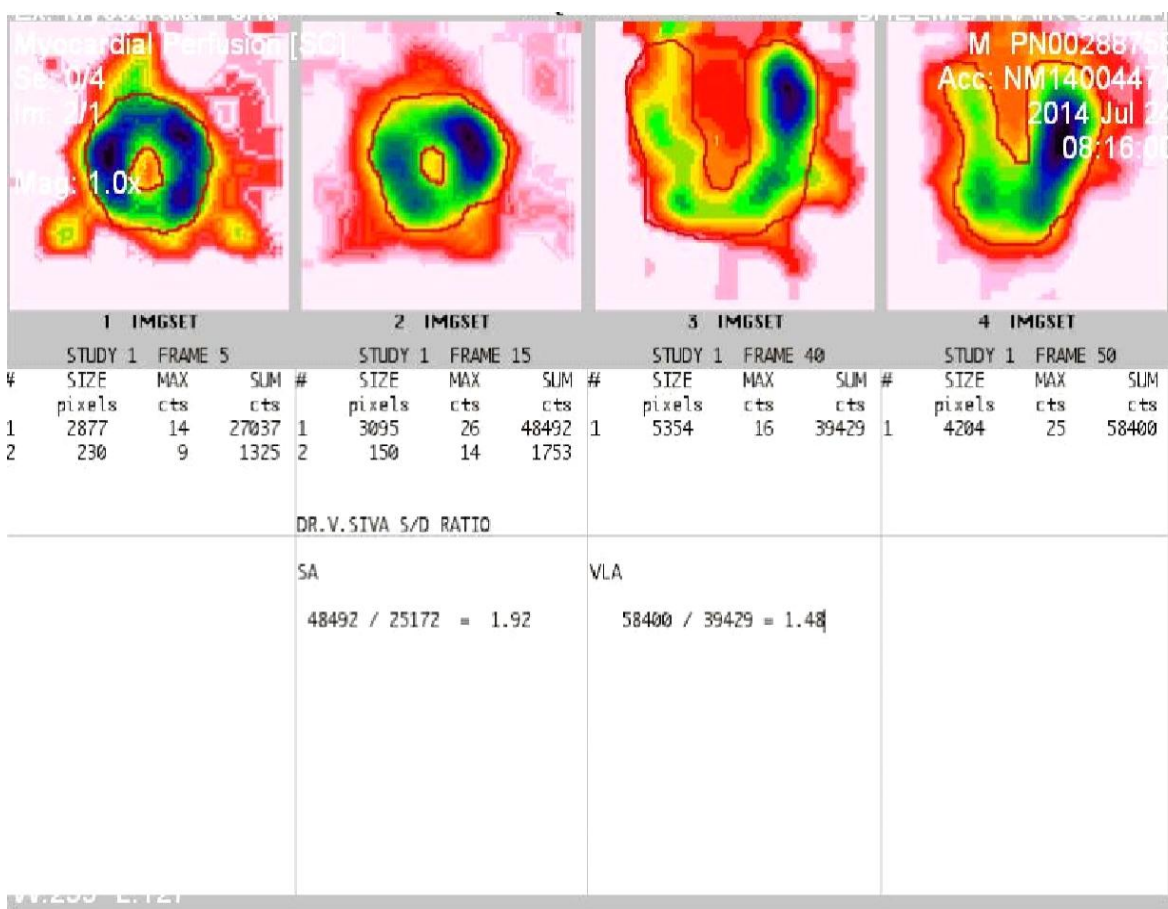

Fig.3 Scintimetric method of calculating Distolic and Systolic for deriving S/D ratio

The systolic and diastolic counts encountered in the male and female patients of the study were tabulated along with the derived S/D ratio in the Fig.4 and Fig 5. The S/D ratios belonging to stage ii and stage iii diastolic dysfunction also were analysed separately.

Fig.4 Male S/D ratio data sheet

NAME	SC	DC	S/D RATIO	NAME	SC	DC	S/D RATIO
ANILKUMAR	13419	6769	1.98		19668	13460	1.48
	13521	9211	1.46		38404	23476	1.6
	16515	12546	1.31		47748	3396	1.4
	25603	20473	1.25	KKDAS	14439	7395	1.95
BANNERJEE D	34937	18552	1.88		15693	11794	1.33
	45910	34152	1.34		27614	18876	1.46
	17198	6617	2.5		39516	24819	1.57
	26876	18718	1.43	K REDDY	156815	116886	1.31
BNAIK SAMAY	48492	25172	1.92		171959	134118	1.28
	58400	39429	1.48	M S JENA	40351	24731	1.63
	24193	10058	2.4		31292	24296	1.28
	28534	16194	1.76	M K PAUL	29543	20595	1.47
CHNADRA O R	61932	56177	1.1		43270	38179	1.13
	62994	52708	1.19		14412	8082	1.7
	27944	17141	1.68		18307	11724	1.56
	22057	17887	1.2	M MUSTAFA	38279	29289	1.3
DASTAGIRI	33712	23280	1.44		32827	29797	1.1
	30622	25351	1.2		12554	6138	2
	12011	6711	1.7		9605	6060	1.58
	9024	5812	1.5	N BABU	64466	39641	1.62
DS	42773	33265	1.28		85114	63104	1.34
	32785	30254	1.08	NR	25894	12819	2.01
	29478	19755	1.49		36390	26415	1.37
	23188	17578	1.32		24239	11760	2.06
B DAS	18086	12770	1.41		30287	15318	1.97
	16279	13864	1.18	OPSAU	32845	20908	1.4
	35562	25653	1.38		34947	23183	1.5
	31553	25120	1.25		13153	7053	1.8
GPAL	13713	6246	2.1		26213	19258	1.36
	11669	6800	1.7				
	17533	13901	1.26			Mean	1.535967742
	16940	9149	1.8			variance	0.205
G BARIK	12052	6788	1.7			Std.devi	0.4528
	19668	13460	1.48				
	38404	23476	1.6				
	47748	3396	1.4				

Fig 5 Female S / D ratio data sheet

N A M E	SYST COUNTS	DIAST COUNTS	S / D RATI0	
FAKRU BI	16492	7892	2.08	
	16273	13864	1.3	
	32753	19595	1.67	
	26920	20528	1.3	
J DEVI	29991	20138	1.48	
	28423	21395	1.32	
	29893	19334	1.5	

	27827	21338	1.3
JBWGUM	24890	19944	1.23
	27359	20180	1.35
	75524	51525	1.46
	79245	72761	1
J BEE BI	24483	11766	2
	37403	25799	1.4
	50888	29066	1.75
	67414	56117	1.2
Kondamma	15524	6950	2.2
	20853	12953	1.6
	54093	30278	1.78
	69373	36734	1.88
Shantamma	23730	21457	1.1
	40885	30719	1.3
	32524	22433	1.44
	49253	34719	1.41
		Mean	1.502083
		variance	0.1389
		standard deviation	0.3726

Results

The discordance between the Diastolic and systolic images were found in 98/100 (98%). The Echocardiographic evidence of Diastolic dysfunction as classified into Grade ii and grade iii using E / A ratio analysis was found in 87/100 (87%). The diabetes was seen in 16/100 (16%) and Hypertension was encountered in 63/100 (63%). The S/D ratio values between the male and female group did not show any significant statistical difference -Fig.6.
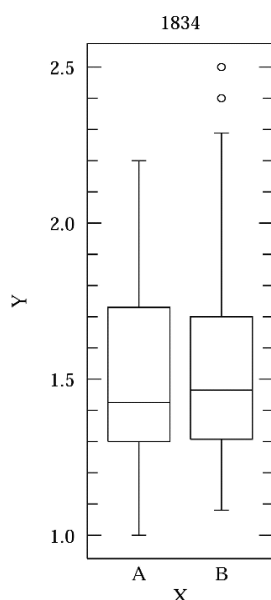

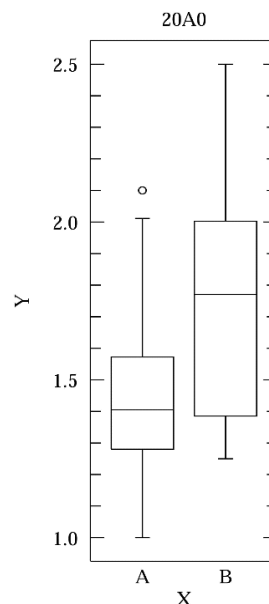Fig.6 No difference between A-Male & B- Female Scintimetric S/D Values

Fig.7 Significant difference between A- Stage ii and B- Stage iii Scintimetric S/D values

The S/D ratio was 1.47 +/- 0.32 in Grade II LVDD and 1.81 +/- 0.03 Grade III LVDD. The statistical analysis of the data with Paired Student t-test confirmed the statically significant difference between the S/D ratio values between the Stage ii and Stage iii grades – Fig.7.

Discussion

This is the first article highlighting the utility of the visual phase image analysis of the diastolic phase images and the systolic phase images in the identification and interpretation of the left ventricular diastolic dysfunction of the heart.By this method 98/100 (98%) of the patients with diastolic dysfunction were identified. Whereas only 87/100(87%) of patients were identified by E / A echocardiographic examination. The visual phase image analysis of detecting the diastolic dysfunction is based on the direct changes occurring in the left ventricular cardiac myocytes hence were able to diagnose the diastolic dysfunction in as high as 98% in our series.In their experience with 16-gated Myocardial Perfusion SPECT assessment of Diastolic Heart Function RD Lele et.al using time volume curve analysis were able to diagnose 92/121 (76%) only [10]. Whereas the direct visual image interpretative assessment of diastolic and systolic phase images resulted in the detection of diastolic dysfunction as high as 98%. However the study should be extended to all remaining the gated SPECT studies to cover larger population.The separate individualized comparison of the ED and ES Perfusions in both stress and rest gated myocardial perfusion imaging findings should also be contemplated. Since this study group did not include normal population a study in normal control group must also be contemplated.

Conclusion

Conclusively it can be said that this method of assessing the radiotracer distribution in the diastolic phase of the cardiac cycle by evaluating the changes occurring in the myocardial muscle tissue directly and correlating it with the presence of Diastolic dysfunction is unique and highly useful in the early detection of the same. The addition of scintimetric quantitation by S/D count ratio to this method will aid in the differentiation of various stages of the left ventricular diastolic dysfunction as well.

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