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EFFECT OF EECP (ENHANCED EXTERNAL COUNTER PULSATION) ON LEFT VENTRICULAR FUNCTION AS MEASURED BY ECHOCARDIOGRAPHY USING STRAIN.

Cardiology

Dr. Sama Akber Resident Dept. of Cardiology Chettinad hospital and research institute.

Prof Dr. M . Chokkalingam* Prof. Dept of Cardiology CHRI. *Corresponding Author

Dr. G. Ashok Associate Prof. Dept of Cardiology CHRI.

Dr. Durga Devi Assistant Prof . Dept of Cardiology CHRI.

KEYWORDS

EECP , 2D echo strain , Heart failure therapy

INTRODUCTION

India stands as one of the fastest developing countries in the world. It has entered quickly into an epidemiological transition leading to a phenomenal increase in non-communicable diseases[1]. Of them leading the way is coronary artery disease. It has been estimated that 40 lakh deaths a year are attributable to cardiovascular disease.[2] The most common symptom in CAD is angina pectoris. The treatment for angina includes medical therapy and coronary revascularization by PTCA or CABG. However, a large number of these patients are not suitable to the usual procedures due to unfavorable coronary anatomy, repeated revascularization attempts, elderly age group, associated comorbidities and patient's preference.

There are many alternative therapies which have been developed recently in management of these patients such as laser revascularization techniques, transcutaneous electrical nerve stimulation, spinal cord stimulation and Enhanced External Counter Pulsation (EECP). EECP is a noninvasive method of treatment which can be done as an Out Patient basis. It has been FDA approved since 1995 and is useful for patients with failed medical therapies and not responding to the routine interventional procedures.[3]

EECP effectively enhances the quality of life of the patient by increasing exercise tolerance, reducing nitroglycerine usage and reducing angina symptoms. It also increases time to ST segment depression. Effects of EECP have reportedly been sustainable over several years (most patients benefit at least upto 5 years)[4]

Evaluation of Left Ventricular (LV) function is a typical indication for echocardiography, which is considered subjective and tedious, notably when the endocardium is not thoroughly visualized. The assessment of LV function seems to vary on the basis of the experience of the echocardiographer (inter-observer variation) and also the software provided by the vendor. The necessity for a conventional quantitative assessment of myocardial systolic function remains as a principal challenge.[5]

Speckle tracking technology has sharpened the diagnostic power of strain echocardiography. the benefits are multiplied by the fact that this can be done offline hence leading to shorter examination times, ease of use and reproducibility. [6,7] it also remains user friendly and angle independent [8] The effect of a complete course of EECP on LV global longitudinal strain (GLS) has never been analyzed in a South Indian population.

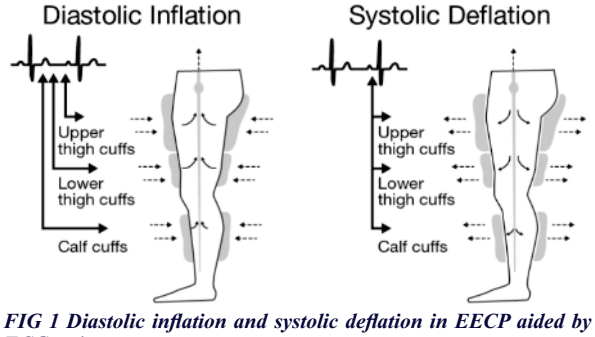


FIG 1 Diastolic inflation and systolic deflation in EECP aided by ECG gating.

The study undertaken has aimed at correlating the benefits of a full course of EECP therapy with the non-invasive assessment of LV systolic function using global longitudinal strain analysis. This was done in the group of population with refractory angina despite best attempts at revascularization and medical therapy.

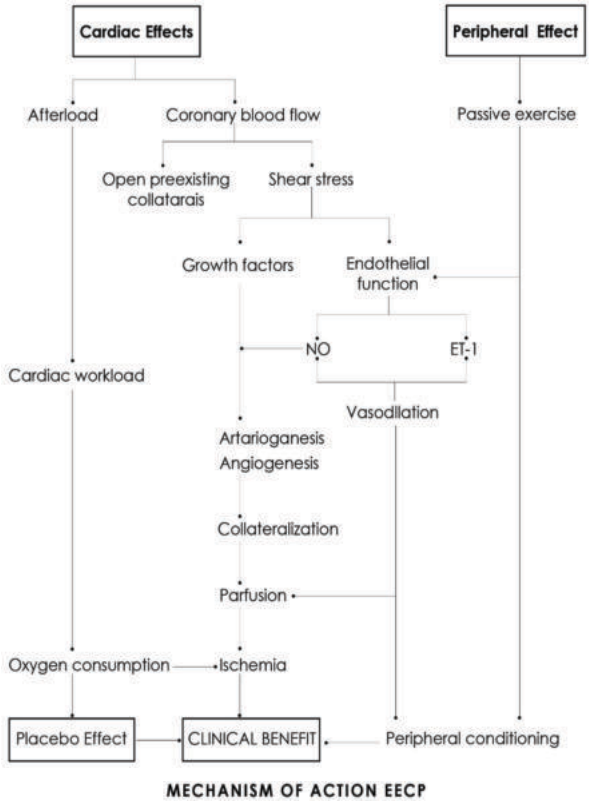


FIG. 2 MECHANISM OF EECP Courtesy : Piero O Bonetti et al[9]

AIMS AND OBJECTIVES

To assess the effects of full course of EECP therapy on LV function using strain echocardiography on patients not amenable to medical treatment or percutaneous revascularization procedures.

MATERIAL AND METHODS

Study setting:

The present study was conducted at Department of Cardiology, Chettinad Hospital and Research Institute, Chennai on patients presenting to OPD with coronary artery disease.

Study population

Fifty patients with coronary artery disease and refractory angina pectoris despite invasive/surgical and pharmacological treatment were enrolled in the study by invitation.

Inclusion criteria:
- Patients with NYHA Class 3 / Class 4 symptoms despite optimal medical management.
- Patients prescribed EECP as coronary anatomy is not amenable to conventional therapy.

Exclusion criteria:
- Acute coronary syndrome within 1 month period
- PTCA or CABG within 3 months
- deep vein thrombosis, aortic aneurysm
- any history of aneurysm repair
- severe peripheral arterial disease
- significant valvular heart disease
- arrhythmia that would interfere with ECG gating
- hypertrophic obstructive cardiomyopathy
- severe aortic regurgitation
- any bleeding diathesis
- severe pulmonary hypertension
- un controlled hypertension (systolic pressure > 180mmHg and diastolic pressure > 100mmHg).
- Pregnant women

Study design:
The present study was undertaken as a cohort study.

Study sample:
This study is planned to include 50 patients with refractory angina pectoris.

Sample Size estimation:
To achieve 95% confidence level with a 5% margin of error, the minimum required sample size was calculated to be 50 using epi info software.

Sampling technique:
Convenient sampling technique was used to select study participants from all the eligible patients who visited the outpatient department.

Study Period:
The study was carried out during the period January 2019 to December 2020.

Brief Procedure:
All patients included in this study will be worked up as follows pre and post EECP therapy: -
1. A detailed clinical history including exercise tolerance assessment.
2. Thorough physical examination.
3. Standard 12 lead ECG
4. 2D Echocardiography with LV Ejection Fraction measured using strain.

Mode of EECP Therapy
1. One hour a day treatment for 35 sessions over 7 weeks.
2. 3 sets of pneumatic cuffs are strapped during the procedure and inflated during diastole timed with ECG gating.
3. The inflation and timings are adjustable and can be optimized till required retrograde pulse wave augments the blood pressure. A monitor shows both ECG signals and cuff pressure levels.
4. Initially trials at lower pressure are started followed by subsequent increase in pressure in the pneumatic cuffs.
5. A desirable maximum pressure of 300 m Hg should be ideal for maximum benefit.

FIG 3 The EECP station

Method of acquiring images for speckle tracking imaging
1. Track the endocardial and epicardial borders of the left ventricle.
2. Correctly define the region of interest (ROI) in the long or short axis view.
3. Post-processing software automatically divides the ventricle into six equally distributed segments.
4. 2D data set is produced.
5. Mathematical algorithms are applied to generate values.
6. Strain curves and bulls eye plot produced showing strain at various segments.
7. Integrated data calculating LV EF and GLS.

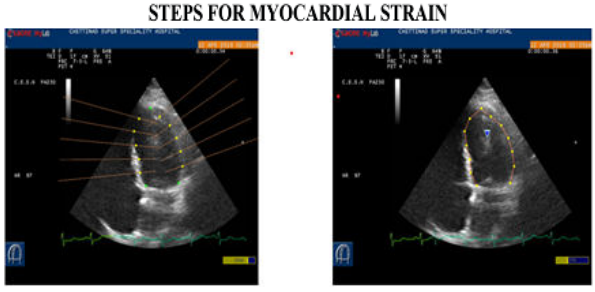


FIG 4 Myocardial strain imaging technique

RESULTS

TABLE 1 **Sex Distribution**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	47	94.0	94.0	94.0
	Female	3	6.0	6.0	100.0
	Total	50	100.0	100.0	

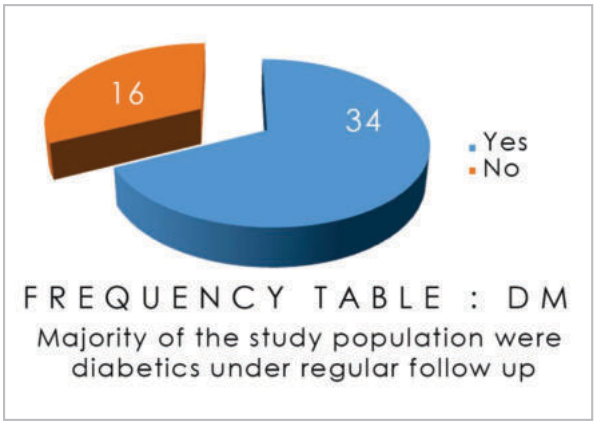
Majority of the study population were male .

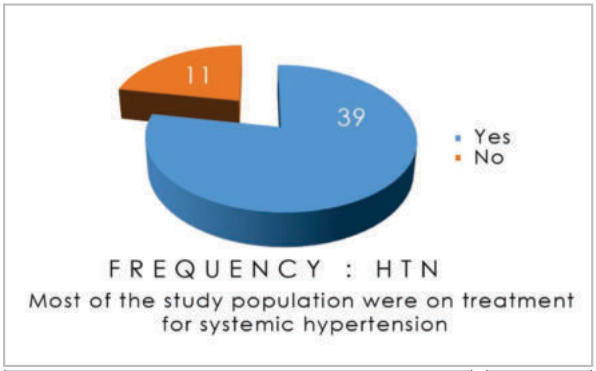
TABLE 2 **Descriptive Statistics (Age , BMI)**

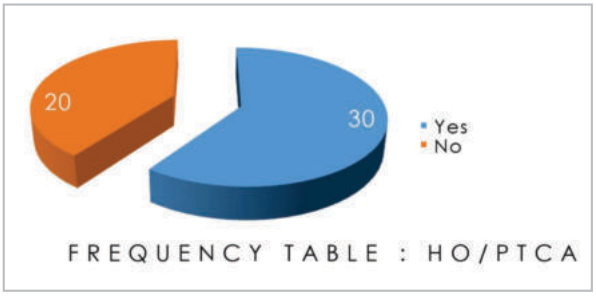
	N	Minimum	Maximum	Mean	Std. Deviation
Age in years	50	35	81	54.64	10.325
BMI	50	18.0	30.9	25.028	3.5299

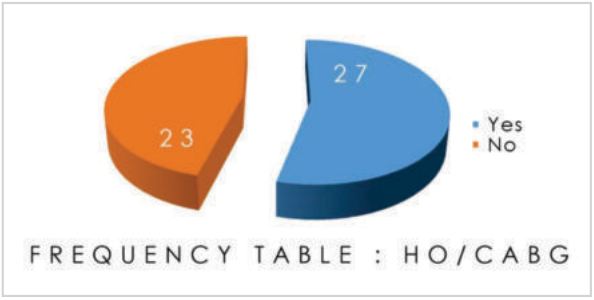
The average age of the study group was 54.64 years with a wide range.

The average BMI of the population was 25.028 which border lined on being overweight.









Tests of correlation of different variables Pre & Post EECP therapy

T-Test

Comparison of EF% pre and post EECP therapy

TABLE 3 correlation between pre & post EECP EF

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	EF% - Baseline	40.6800	50	8.50316	1.20253
	EF% - Post	47.6400	50	6.22621	.88052

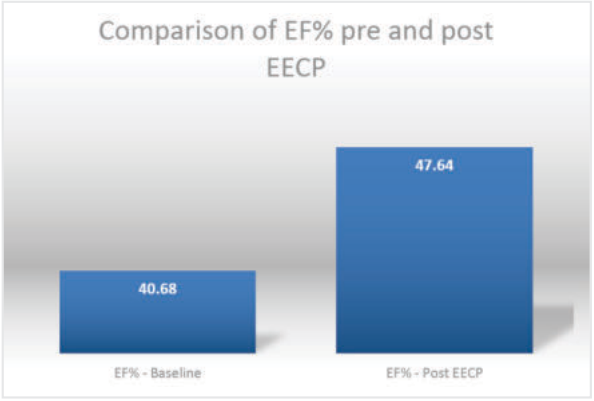


Fig 5 comparison of Pre Vs post EECP EF

There is an increase of nearly 7% post EECP .

TABLE 4 paired sample T test Pre vs post EECP (EF)

		Paired Differences					t	df	Sig. (2-tailed) P value
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	EF% - Baseline - EF% - Post	-6.96000	3.44615	.48736	-7.93938	-5.98062	-14.281	49	.000

This raise in EF was determined to be statistically significant using the paired Students t- test

Comparison of GLS pre and post EECP

T-Test

TABLE 5 **Paired Samples Statistics GLS pre and post EECP**

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	GLS - Baseline	-15.9860	50	2.06970	.29270
	GLS - Post	-17.3660	50	2.17280	.30728

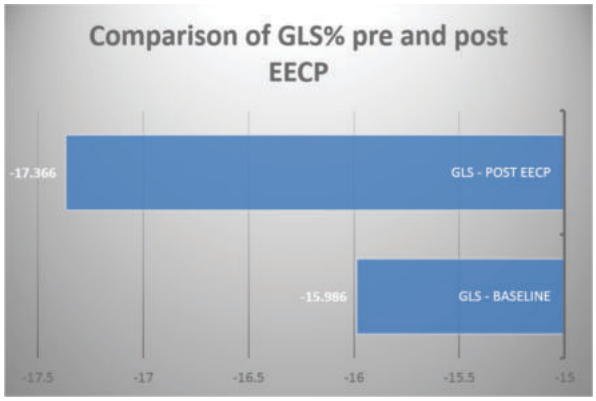


Fig 6 Comparison of GLS pre and post EECP

There was a improvement in the GLS post EECP of nearly 1.5%.

TABLE 7 **Paired Samples Test GLS pre and post EECP**

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	GLS - Baseline - GLS - Post	1.38000	.98188	.13886	1.10095	1.65905	9.938	49	.000

This determined to be statistically significant using the paired Students t- test

DISCUSSION

The purpose of our study was to establish a clear cut relationship between the onset of EECP therapy and improvement in GLS and Ejection fraction. The study population was predominantly male with an average age of 54 years. The BMI was a mean of 25.028 border lining overweight category. The majority of the population were diabetic - 68% (n=34) and hypertensive 78%(n= 39). All the participants included in the study had undergone some form of revascularization either PTCA (n=30) , CABG (n=27) or both (n=11). To begin with the average baseline EF was 40.6% which improved to 47.64 % and on analysis it was found to be statistically significant. The GLS assessed pre EECP was a mean of -15.98% compared to a post EECP value of -17.36% and on analysis this to was statistically significant. All subgroups DM, HTN, PTCA , CABG showed statistically significant improvements in both EF and GLS. This was interestingly seen even in the non diabetic and non hypertensive population.

Our study was in concurrence with previous studies in the fact that it improved functional class with all patients reporting at least 1 class of reduction in either dyspnea (NYHA) or angina Canadian Cardiological Society (CCS) as seen in MUST- EECP and IEPR(described in table no.) These landmark studies also compared long term outcomes with EECP showing reduction of up to 83% in hospitalization , compared to 6 months prior to EECP.

Urano et al conducted a study in patient with refractory chronic stable angina, EECP therapy significantly improved LV diastolic dysfunction but did not show significant improvement in LV systolic function .

However Arora et al[3] and Esmaeilzadeh M et al[10] in their respective studies showed improvements in LV systolic function in terms of EF and the later even showed improvements in strain rate measurements.

Management of patients who have exhausted their options for revascularization and remain symptomatic on optimal medical management is very challenging . By incorporating EECP into the armamentarium of treatment options in this group greatly improves the not only LV systolic function but also gives a training effect on the heart as observed by Stys TP et al[11] in his study. Our study also demonstrated similar effects by showing improvement in NYHA functional class of at least 1 in all participants.

The large heart failure group refractory to therapy usually suffer not only with failure symptoms but also psychological aspects such as depression. In the PEECH trial there was a significant increase in EF and also a significant improvement in Minnesota Living with heart failure score[12]. This index takes into account psycho-social aspects of heart failure. This was in concurrence in our study group as evidence by a 100% completion of EECP therapy. All patients in our study showed a good response to therapy and did not have short term readmission and had good adherence to therapy. The long term follow up was not assessed in our study.

Though hypertension and blood pressure control was not included in our study aim it was measured in our OPD and the patients had better regulation than prior to EECP therapy. This is in concurrence with a previous study done at our institution by Ramaswamy S et al[13]. The larger hypertensive population of our study showed a greater improvement in EF and GLS % than the non hypertensive group.

SUMMARY & CONCLUSIONS

Central cardiac effects have been postulated to be a major mechanism in exerting the beneficial effects of EECP.

Improved endothelial function, increased coronary collateral blood, neoangiogenesis all play an important role in the central effects of EECP.

EECP also exerts benefits by peripheral effects by increased shear stress and enhanced venous return and increased peripheral blood flow. Psycho social benefits of EECP though not immediately apparent have been shown to improve as evidenced by an improved quality of life index (Minnesota living with heart failure index) and reduction in angina and or dyspnea class in almost all recipients.

A non invasive largely beneficial therapy could be a good solution as an adjunct in mainstream treatment of a group of population who have otherwise exhausted all other options of treatment.

Global longitudinal strain is a fast , reliable indicator of LV systolic function .

It has been proven to be more prognostic than traditional EF measurement and asses the entire contractility of the heart.

The present study showed benefit to all the participants undergoing EECP therapy. This was further made clear with the application of GLS as a additional echocardiographic parameter along with traditional 2D echocardiographic LV function.

The participants all showed improvement in functional NYHA dyspnea class. We recommend the use of EECP in patients with refractory angina and heart failure symptoms and advocate their assessment with GLS as an additional non invasive parameter for measuring LV function.

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