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VALUE OF 3D SPECKLE TRACKING ECHOCARDIOGRAPHY IN ASSESSMENT OF LEFT VENTRICULAR SYSTOLIC MECHANICS BEFORE AND AFTER MITRAL VALVE REPLACEMENTIN PATIENTS WITH SEVERE PRIMARY MITRAL REGURGITATION

By

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ABSTRACT

Background: The mitral valve repair or replacement is indicated for patients with symptomatic mitral incompetence. When operative treatment is being considered, the chronic and often slowly but relentlessly progressive nature of MR must be weighed against the immediate risks and long-term uncertainties attendant onsurgery, especially if mitral valve replacement (MVR) is required.

Objectives: Tostudy and assess the left ventricular function in patients with mitral valve incompetence before and after mitral replacement. By real-time 3-dimensional (3D) speckle tracking echocardiography (RT3D-STE).

Patients and methods: The ethical approval was obtained from the hospital ethical research committee and each patient entering the study signed an informed consent. The study involved 40 patient with severe primary mitral regurgitation collected from the Cardiology clinic of Al-Azhar University Hospitals. The patients were screened for the study enrolment prospectively. The study was performed at Islamic cardiac center of cardiology, Al-Azhar University at the period from June 2019 to April 2020.Detailed history, physical examination, resting ECG, conventional 2D echocardiography assessment, strain imaging with measurement of LV-GLS 2D speckle tracking and RT3D-STE (Left ventricular ejection fraction (LVEF), and global longitudinal, area, radial, and circumferential strain (GLS, GAS, GRS, and GCS).

Results: Real time 3D speckle tracking echocardiography was an echocardiographic modality that could detect early and subtle LV dysfunction in patients with mitral regurgitation.

Conclusion: Real time 3D speckle tracking echocardiography could detect early and subtle LV dysfunction in patients with mitral regurgitation and could predict prognosis of the patient and determine the time of surgery in which the patient could get the most value.

Abbreviation: MVR: mitral valve replacement, LV: left ventricle, GLS: global longitudinal strain, GAS: global area strain, GCS: global circumferential strain, GRS: global radial strain

Keywords: MVR, Echocardiography, Real-Time 3-Dimensional Speckle Tacking Imaging, Left Ventricular Function.

INTRODUCTION

The field of mitral valve disease diagnosis and management is rapidly changing. New understanding of disease pathology and progression, with improvements in and increased use of sophisticated imaging modalities, have led to early diagnosis and complex treatment *(Nishimura et al., 2016).*

In severe primary mitral regurgitation, the chronic elevation of wall stress caused by the resulting volume overload leads to structural remodeling of the muscular, vascular and extracellular matrix components of the myocardium. These changes are initially compensatory but in the long term have detrimental effects, which ultimately result in heart failure. Understanding the changes that occur in the myocardium due to volume overload at the molecular and cellular level may lead to medical interventions, which potentially could delay or prevent the adverse left ventricular remodeling associated with primary mitral regurgitation *(Keir and Pravin, 2018).*

The predominance of valvular disease has shifted from a rheumatic to a degenerative aetiology in industrialized countries, leading to important changes in patient characteristics and in the distribution of the type of valvular lesions *(IungandandVahanian, 2011).*

The mitral valve repair or replacement is indicated for symptomatic patients. When operative treatment is being considered, the chronic and often slowly but relentlessly progressive nature of MR must be weighed against the immediate risks and long-term uncertainties attendant on surgery, especially if mitral valve replacement (MVR) is required *(Regueiroet al., 2017).*

Assessment of LVEF may be carried out by either conventional echocardiogram or by speckle tracking strain imaging and several studies emerged over last five years reporting the use of speckle tracking strain imaging to detect subtle changes in the ventricles *(Yokokawa et al., 2012).*

Traditional echocardiographic methods may not effectively evaluate subtle and early forms of PVC-induced ventricular function impairment. Real-time 3-dimensional (3D) speckle tracking echocardiography (STE), an advancement over conventional 2-dimensional (2D) STE, provides a new, convenient and non-invasive method for quantitative evaluation of cardiac function by allowing to measure strain values, better capturing 3D cardiac motion and addressing the failure of 2D-STE to track out-of-plane speckle motion *(D'Ascenziet al.,2016)*.

In recent years, three-dimensional speckle-tracking (3DSTE) has been implemented for measuring 3D strain, and has emerged as a more physiologically sound tool for analyzing the complexity of LV mechanics, overcoming the inherent limitations of 2DSTE. Due to the superiority provided by the addition of the third dimension for myocardial deformation analysis (e.g., no through-plane motion of speckles, ability of tracking the speckles in two directions simultaneously for area strain quantification, etc.), 3DSTE has the potential to become the gold-standard technique for assessing LV systolic function by echocardiography in the near future *(Muraru et al.,2018).*

The aim of this work was to assess feasibility of real-time three-dimensional speckle tracking echocardiography in assessment of left ventricular systolic mechanics before and after mitral valve replacement in patients with severe primary mitral regurgitation.

PATIENTS AND METHODS

This pilot study involved 40 patient with severe primary mitral regurgitation planned for MV replacement "before and after the replacement" and collected from the Cardiology clinic of Al-Azhar University Hospitals. The patients were screened for the study enrolment prospectively. The study was performed at Islamic Cardiac Centre of Cardiology, Al-Azhar University during the period from June 2019 to April 2020The protocol and all corresponding documents were approved by the Ethical and Research Committee, Faculty of Medicine, Al-Azhar University and patients provided informed consents. The studied groups were forty patients with severe primary mitral regurgitation planned for MV replacement "before and after the replacement.

Inclusion criteria:

Patients have severe primary mitral regurgitation, degenerative mitral valve disease, Rheumatic mitral incompetence and mitral valve prolapse.

Exclusion criteria:

Ischemic heart disease or RWMAs detected by echocardiography, aortic valve diseases more than mild degree, MS more than mild degree, pericardial surgery, cardiomyopathies, myocardial surgery, congenital heart disease surgery, chronic kidney disease, previous mitral valve intervention and poor echogenicity.

The clinical information of study population was recorded, such as age, gender and cardiovascular risk factors including smoking, hypertension, and diabetes. The clinical data, including heart rate (HR), and body mass index (BMI), were measured. 12 lead surface ECG and chest x-ray were recorded.

Echocardiographic data were acquired with an ultrasound Vivid E9 system (GE Vingmed Ultrasound AS, Horten, Norway), which was equipped with two-dimensional 3.5-MHz transducer (M5S-D), three - dimensional 3.5-MHz transducer (4C-D), off-line speckle-tracking analysis software, and background processing workstation (Echo PAC BT 11.1.0, GE Medical System, Horten, Norway). During the examination, all subjects were connected to the ECG and maintained in the left lateral decubitus position.

Two-Dimensional Echocardiography and Measurements: All the patients were examined in the left lateral decubitus position. Echocardiographic images were acquired from the standard views (parasternal long-axis, parasternal short axis at level of the great vessels, apical four–chambers, apical five–chambers and apical two-chambers). Recordings and calculations of different cardiac chambers and ejection fractions were made according to the recommendations of the American Society of Echocardiography *(Lang and Roberto, 2015).*

Three-Dimensional Echocardiography and Measurements: The 3-dimensional volumetric transducer was used to obtain a clear image of the LV endocardium with

an apical 4-chamber view in the 4-dimensional mode. The imaging allowed a sector with a depth of 30°and a width of 100°in real time. Then the larger pyramidal volume which was combined by small real time sub volumes of 4 to 6 cardiac cycles were collected and stored. Three dimensional left ventricular end-diastolic volume, left ventricular end-systolic volume (LVESV), and GLS, GAS, GCS and GRS were obtained by the dedicated software *(Gorcsanand Tanaka, 2014)*. Patients with poor visualization (more than 2 segments) were excluded from further investigation.

Statistical analysis:

Data were analyzed using Statistical Program for Social Science (SPSS) version 20.0 IBM, Armonk, NY, United States of America. Quantitative data were expressed as mean± standard deviation (SD). Qualitative data were expressed as frequency and percentage. Independent-samples t-test of significance was used when comparing between two means. Chi-square (X2) test of significance was used in order to compare proportions between two qualitative parameters.

RESULTS

The study included 23 males and 17 females. The mean age was 44.6±5.67.There was no statistically significant difference (P-value > 0.05) between the patients and control as regarding factors risk: 19 diabetic patient (47.5%) and 21(52.5%) hypertensive patient, while in control group 5 patients (25%) have diabetes and 6 patients (30%) have hypertension.

As regard comparison between pre and post-operative data showedno statistically significant difference between groups using conventional echocardiography except in LVEDD **(Table 1)**.

Table (1): Comparison between pre and post-operative data according to conventional echocardiography

Parameters \ Data		Pre (N=40)			Post (N=40)			p. value
LVEDD(cm)	Range	4.72	–	6.7	4.3	–	6.6	0.007*
	Mean±S. D	5.61	±	0.60	5.13	±	0.55	
LVESD(cm)	Range	2.9	–	4.6	3	–	4.6	0.445
	Mean±S. D	3.74	±	0.48	3.66	±	0.46	
LVEDV(ml)	Range	103.38–231.36			97.34–223.61			0.129
	Mean±S. D	169.06	±	33.97	157.63±32.75			
LVESV(ml)	Range	32.21	–	97.34	35	–	97.34	0.432
	Mean±S. D	61.25	±	18.40	58.08	±	17.49	
LVEF (%)	Range	55.44	–	77.24	45.16	–	77.24	0.567
	Mean±S. D	64.09	±	6.18	63.19	±	7.69	
LAD(cm)	Range	4	–	6.1	3.2	–	5.8	0.185
	Mean±S. D	4.73	±	0.50	4.57	±	0.54	
AOD (cm)	Range	2.4	–	3.6	2.2	–	3.6	0.134
	Mean ± S. D	3.03	±	0.34	2.91	±	0.35	

Comparison between pre and post-operative data showed a statistically significant difference between groups using 2D Speckle tracking echocardiography GLS. And as regard comparison between pre and post-operative data there were statistically significant difference between groups using 3D Speckle tracking echocardiography GLS, GCS, GAS, GRS **(Table 2)**.

Table (2): Comparison between pre and post-operative using 2D Speckle tracking echocardiography GLS and 3D Speckle tracking echocardiography GLS, GCS, GAS, GRS

Parameters \ Data		Pre (N=)			Post (N=)			p. value
2DST-GLS (%)	Range	13	–	24	13	–	24	0.011
	Mean ± S. D	17.13	±	2.93	15.50	±	2.64	
3DST-GLS (%)	Range	14	–	24	12	–	20	0.023
	Mean ± S. D	17.05	±	2.35	15.85	±	2.28	
3DST-GCS (%)	Range	10	–	19	9	–	20	0.043
	Mean ± S. D	15.15	±	2.29	14.15	±	2.06	
3DST-GAS (%)	Range	22	–	35	19	–	33	0.036
	Mean ± S. D	27.73	±	3.69	25.83	±	4.25	
3DST-GRS (%)	Range	31	–	48	26	–	43	0.040
	Mean ± S. D	38.90	±	4.61	36.95	±	3.71	

As regard comparison between pre and post-operative using 3D Speckle tracking echocardiography GAS (Table 3).

Table (3): Comparison between pre and post-operative using 3D Speckle tracking echocardiography GAS

Post \ Pre	< 26 (n=12)	26 – 29 (n=15)	> 29 (n=13)
< 26 (n=18)	12	6	0
26 – 29 (n=12)	0	7	5
> 29 (n=10)	0	2	8
P value	0.001		

DISCUSSION

In the present study, 40 consecutive patients (aged 32 - 55 years, mean 44.6±5.67) 57.5% of the studied patients were males and 42.5% of them were female all with sever MR .Regarding 2D conventional echocardiographic parameters, in pre and post-operative group mean LVEDD, there was significant statistical difference. LVEDV, LVESD and LAD in pre and post-operative group showed no statistical significance. Also, LVEDV in pre-operative group and post-operative group showed no statistically significance and the same regarding LVESV. These findings coincided with *(de Isla et al., 2009)* who found only statistical significant difference in LVEDD. *Pandis et al. (2011)* noticed decrease in LV EDD in post-operative patient's with statistical significant difference values. But in

contrast to our study he found statistical significant difference in LVESD between pre and post-operative patients. There was a decrease in EF in post-operative patients although there was no statistical significance between pre and post-operative groups. This result coincided with *(de Isla et al., 2009)* who found decrease in LV EF post operatively with statistical significant difference values.

Pandis et al. (2011) found decrease in LV EF but with statistical significant difference values, however this difference may not be accurate preoperatively as the left ventricle have a pseudo-overestimated EF owing to the volume overload.2D speckle tracking variables of global function, in our study showed a significant difference regarding LV-GLS between case and control groups. Global values of LV were significantly lower in the post-operative group than in the pre-operative subjects. This coincided with *Cho et al. (2016)* who found significant decrease in LV GLS.

Regarding RT 3D speckle tracking variables of global function, there were significant differences regarding strain values of (LV-GLS, LV-GAS, LV-GRS, and LV-GCS) between pre and post-operative group. Global values of LV-GLS were significantly lower in the post-operative group than in the pre-operative group. This result was found in contrast with *Pandis et al. (2011)* who found improvement of LV GLS post-operatively. Global values of LV-GRS were significantly lower in the post-operative group than in the pre-operative group. These data were against data obtained from *Pandis et al. (2011)* who found increase in LV GRS post operatively; this could be due to difference in number of patients and equipment.

Global values of LV-GCS were significantly lower in the post-operative group than in the pre-operative group. These data coincided with data of *Kim et al. (2018)* who found significant statistical difference in post-operative patients. Global values of LV- GAS were significantly lower in the post-operative group than in the pre-operative group. In this study, we noticed that patient with normal GAS get the most benefits from early surgery. There was no impairment in their GAS values after surgery such data were also found by *Pandis et al. (2011).*

CONCLUSION

Real time 3d speckle tracking echocardiography could detect early and subtle LV dysfunction in patients with mitral regurgitation and could predict prognosis of patient and determine the time of surgery in which the patient could get the most value.

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قيمة التتبع النقطى بالموجات فوق الصوتية ثلاثية الأبعاد فى تقييم وظيفة البطين الأيسر الانقباضى فى مرضى إرتجاع الصمام الميترالى الأولى الشديد قبل وبعد تغيير الصمام

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خلفيـــة البحـــث: يعـد اسـتخدام الموجـات فـوق الصـوتية ثنائيـة الابعـاد مـن الاشـياء المهمـة فـى تشـخيص مـرض ارتجـاع الصـمام الميترالـى الاولـى ويترتـب عليـه القـرار فـى عـلاج هـؤلاء المرضـى لكنهـا لاتمـدنا بكافـة المعلومـات ولا التنبـوء بدرجـة الاصـابة ومـع تطـور التقنيـات الحديثـة للتصـوير عـن طريـق الموجـات الصـوتية ثلاثيـة الابعـاد اصـبح مـن الممكـن التنبـؤ بـالتغيرات والتـاثيرات المبكـرة لارتجـاع الصـمام الميترالـى علـى القلـب وخاصـة البطـين الايسـر ولـيس هـذا فحسـب بـل يمكـن اسـتخدامه فـى تحديد قرار العلاج المناسب واالتنبؤ بالاستجابة للتدخل الجراحى.

الهـدف مـن البحـث: تحديـد قيمـة الموجـات فـوق الصـوتية ثلاثيـة الابعـاد فـى تشـخيص وظـائف البطـين الايسـر فـى المرضـى الـذين يعـانون مـن ارتجـاع أولى شديد بالصمام االميترالى قبل وبعد تغيير الصمام.

المرضـى وطـرق البحـث: تمـت إجـراء الدراسـة علـى أربعـين شخصـاً مريضـاً يعـانون مـن إرتجـاع أولـى شـديد بالصـمام الميترالـى وتقـرر لهـم اجراء تدخل جراحى.

نتـائج البحـث: أسـفرت الدراسـة عـن قـدرة الموجـات الصـوتية ثلاثيـة الابعـاد بـالتنبوء المبكـر للاعـتلال الخفـى فـى وظـائف البطـين الأيسـر الانقباضـى فـى مرضـى إرتجـاع الصـمام الميترالـى مقارنـة للتقنيـات

الأخـــرى عـــن طريـــق الموجـــات فـــوق الصـــوتية ثنائيـــة الأبعاد،كمـــا اســـفرت عـــن قـــدرتها فـــى التنبـــوء بمـــا تـــؤول إليـــه وظـــائف البطـــين الأيســـر مـــن تحســـن او عدمه بعد إجراء الجراحة.

الإســـتنتاج: إســـتخدام الموجـــات فـــوق الصـــوتية ثلاثيـــة الأبعـــاد فـــى تقيـــيم مرضـــى إرتجـــاع الصـــمام الميترالـــى لـــه القـــدرة علـــى التنبـــوء وتحديـــد التوقيـــت المناسب للجراحة ومدى الاستفادة منها.