Original Article

PLAIN GATED 64 SLICE MULTI DETECTOR COMPUTERIZED TOMOGRAPHIC (MDCT) ASSESSMENT FOR DYSFUNCTION OF PROSTHETIC HEART VALVE

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Submission Date : 28-01-2020
Revision Date: 27-02-2020
Publication Date: 20-03-2020

Author's Contribution

TN:Conceive the idea and conducted the study and wrote the article. MAN:Helped in review the article. AR: Helped in Data analysis and Re-arranged data IS: Reviewed the article and helped in correctionTables and figures. BSM: made corrections and did the proof reading.MA: Helped in conceving the idea and overall review of the article.

All authors declare no conflict of interest.

This article may be cited as: Naveed T, Naqvi MA, Rashid A, Saeed I, Mohydin BS, Ayub M. Plain Gated 64 slice multi detector computerized tomographic (MDCT) assessment for dysfunction of prosthetic heart valve. J Cardiovasc Dis 2020;16(1):3 - 9

ABSTRACT

BACKGROUND: Prosthetic Heart Valves (PHV) dysfunction is a rare but serious complication. Early diagnosis with imaging is essential. The most common diagnostic imaging is TTE, TEE and fluoroscopy.

The objective of this study was to assess dysfunction of PHV on MDCT.

MATERIAL AND METHODS: This study was done at Punjab Institute of Cardiology from January 2018 to December 2018 .Inclusion criteria was patients who had prosthetic valve replacement and presented with shortness of breath, and had increased transvalvular mean gradients across prosthetic heart valve on transthoracic echo. Thirty consecutive patients with increased gradient on Echocardiogrpahy were enrolled. The patients who had inability to hold the breath, and contraindication to radiation were excluded. Plain gated MDCT of the heart was done on low voltage and tube current to reduce the radiation dose. Retrospective gated data was analyzed for the assessment of prosthetic heart valve. CT cine data was analyzed for visual assessment of the mobility of discs of the valves along with opening and closing angles were noted for valve function.

RESULTS: A total of thirty patients were analyzed for prosthetic heart valve dysfunction. Among these nineteen were males and eleven were females.The total number of prosthetic valves assessed on MDCT were thirty nine.Ten (29.41%) bi-leaflet prosthetic valves had adequate mobilityof both discs and opening(75^0-85^0)and closing angles(25^0-30^0)signifying normal function of the valves and twenty-four bi-leaflet valves (70.58%) had restricted mobility of the discs of the valves either one or both. Among the four Starr Edwards prosthetic valves three had normal mobility of the ball and one patient had restricted mobility of the ball in the cage. Only one patient had single disc valve which had normal mobility of the disc having opening and closing angle of 65^0 and 0^0 respectively .Thirteen patients had MVR,09 patients had AVR,07 patients had DVR and one patients had Triple valve replacement. Mean radiation dose of plain gated MDCT in mSv was -3.03±0.91 Max 5.1 min 1.6 mSv.

CONCLUSION: Plain gated MDCT is capable to assess the prosthetic heart valve dysfunction either alone or in combination with fluoroscopy and transthoracic echocardiography.

KEY WORDS: Prosthetic heart valve(PHV), Multi detector Computerized tomography(MDCT),PGSC

(J Cardiovasc Dis 2020;16(1):3 - 9)

INTRODUCTION

World wide over 100 million people are affected by the valvular heart disease. The major cause of this is degenerative valve disease in ageing population in the developed world and rheumatic heart disease in the developing world[1].

Prosthetic Heart Valves (PHV) replacement is an important therapeutic option in patients with valvular dysfunction. Large number of patients undergo PHV replacement[2]. PHV function can be assessed by different imaging modalities. The most important among these are Trans Thoracic Echocardiography (TTE) Trans Esophageal Echocardiography, (TEE) and fluoroscopy. Multi Detector Computed Tomography (MDCT) has been added to these imaging modalities for the assessment of PHV. PHV dysfunction is a life threatening complication, which needs an early and accurate diagnosis. In daily routine clinical practice PHV dysfunction is assessed on TTE, TEE and on fluoroscopy, which helps in early diagnosis. The common causes of PHV dysfunctions are pannus formation, thrombus formation, infective endocarditis and valvular or paravalvular leak.[3,4]

MATERIALS AND METHODS:

This study was done at Punjab institute of cardiology between January 2018 and December 2018. The patients which were included in the study had come in the cardiac emergency of Punjab Institute of Cardiology who had either single valve replacement (SVR) or double valve replacement (DVR) and presented with shortness of breath. These patients had increased mean transvalvular pressure gradient across the prosthetic valve on TTE. Exclusion criteria was refusal for the MDCT, inability to hold breath for 10 seconds and contraindication to radiation.

DEFINITIONS:

PROSTHETIC VALVE DYSFUNCTION:

This was defined: 1. An increased mean pressure gradients on TTE across mitral valve (6-10 mmHg possible stenosis $\geq$10 mmHg definite stenosis) and across aortic valve 20-35 mmHg possible stenosis $\geq$35 mmHg definite stenosis and across tricuspid valve-(>6 mmHg) definite stenosis . 2. Stuck up and or restricted mobility of one or both discs in case St. Jude Valve and ball in case of Starr Edwards prosthetic valve.[5]

Bileaflet valves are two semilunar disks which are attached to metallic ring by small hinges. The normal opening angles of the discs ranged from 75^0-85^0 which is in diastole in case of valve at mitral position and in systole in case of valve at aortic position. The closing angle in bi-leaflet metallic valve is 25-30 degree which is in diastole in case of aortic valve prosthesis and in systole in case of mitral valve prosthesis .

In case of single disc the closing angle of 0^0 and opening angle of 60-70^0 was normal.[6]

The threshold of patient prosthesis mismatch (PPM) at aortic position was 0.85 cm^2/m^2 and values between 0.68-0.85 cm^2/m^2 is moderate PPM and < than 0.65 cm^2/m^2 as severe mismatch.[7]

MDCT analysis of bi leaflet St Jude valve was done by analyzing the disc movement in systolic (30-40 % phases) and in diastolic (70,80,90%) phases and in cine mode. The opening and closing angles were visually analyzed and adequate mobility was defined as achieving an angle of 30^0 from the annular plain in closing position and achieving an angle of 75-85^0 from the annular plain which is a virtual plain in opening position for bi-leaflet prosthetic valves at aortic and mitral positions. For Starr Edwards ball cage valve upward and down ward mobility of ball in systolic and diastolic phases was considered as normal and lack of movement was considered as dysfunction of the valve.

MDCT PROTOCOLS AND IMAGE ANALYSIS:

Computed tomographic studies were performed on a 64-slice MDCT (Light-speed VCT; GE Healthcare, Milwaukee, WI, USA). The MDCT protocol was as follows: slice collimation (64$\times$0.625 mm), gantry rotation time (350 ms), table feed (6 mm/s), tube voltage (100 kV), and tube current (200 mAs).

All examinations were performed using retrospective electrocardiographic gating. Image data was reconstructed using the cardiac image reconstruction algorithm provided with the scanner. Images were reconstructed at consecutive 10% increments of the (R-R) interval, yielding 10 phases of information. All post-processing was performed on a GE AW Workstation (Advantage Windows Workstation 4.4), using the Card IQ function software (GE Healthcare). Image data was reconstructed in the vertical and parallel images of the MV. The opening and closing angles of the prosthetic bi leaflet metallic valve at mitral, aortic and tricuspid positions, were selected visually for image analysis. Window settings were adjusted to properly visualize the valve with less beam-hardening artifact.

For mechanical PHVs, the leaflet opening and closing angles were measured and cine images reconstructed for evaluation of symmetrical leaflet

excursions. Three sets of images were reconstructed in three perpendicular imaging plains. Each PHV were set in plain with the valve, one set parallel and one set perpendicular to the valve leaflet(s). Reconstructions were made in both the diastolic and systolic phase of the cardiac cycle.

The dose-length product DLP (mGy*cm) extracted from the MDCT dose reports and the conversion factor for adult chest MDCT examinations (0.017 mSv/mGy*cm) were multiplied to acquire the effective radiation dose per patient in (mSv)

The patients did not receive any additional premedication's, such as β-blockers, for control of their heart rate.

STATISTICAL ANALYSIS:

It was performed with SPSS 19.0. Descriptive statistics were reported as mean, standard deviation, median, minimum, and maximum values for continuous variables and as frequency and percentages for the categorical variables.

RESULTS:

A total of thirty patients were included and 39 valves were analyzed for prosthetic heart valve dysfunction. Among these nineteen were males and eleven were females. The basic demographic and TTE parameters are shown in the table 1.

The table-2 shows the distribution of the PHV. Mean radiation dose of MDCT without contrast was 3.03±0.91 Max 5.1 min 1.6 mSv.

Table-3 shows the distribution of normal and dysfunction valve as assessed on MDCT. Ten (29.41%) bi-leaflet prosthetic valves had adequate mobility and normal function of the valve signifying the opening angles of 75^0 - 85^0 and closing angle of 25^0-30^0 and twenty-four (70.58%)valves had restricted mobility of the discs of the valves either one or both. Among the four Starr Edwards prosthetic valves three had normal mobility of the ball and one patient limited mobility in the cage. Only one patient had single disc valve which had normal mobility of the disc having opening and closing angle of 0^0 and 65^0 respectively.

Among thirty patients there were sixteen patients who had AVR .Out of these eleven had increased mean gradient across the aortic valve(mean gradient was 47.7 ±4.9mmHg). Seven patients had restricted mobility of the discs of bi-leaflet valve. Four had adequate mobility and normal opening and closing angles and had smaller valves and were assessed for patient prosthesis mismatch by administering the contrast. Five patients had normal mobility of both the discs of St. Jude Valve.

Among thirty patients twenty-one (53.8%) patients had MVR and 07 (33.3%) had normal function of mitral valve prosthesis. Fig and 14 (66.66%) had malfunction of mitral valve pros-

Table-1: Basic Demographic and echocardiographic parameters

Males	19 (63.66%)
Females	11(36.66%)
Average Age(years)	41.28 ±14.2Max 65,Min 17
BMI	22.9 4.2±
Mean radiation dose of MDCT without contrast (msv)	3.03±0.91 Max 5.1 min 1.6
INR (mean)	1.8±0.42 Max 2.6 min 1.0
MVPG (mean)mmHg	22.92 ± 4.1
AVPG(mean) mmHg	47.71 ±4.91

Table-2: Total number of prosthetic valves assessed on MDCT and their distribution.

Triple Valve Replacement (TVR) MVR, AVR, Tricuspid Valve Replacement	01
DVR (MVR +AVR)	06
DVR (MVR+ Tricuspid VR)	01
MVR	13
AVR	09
Total	39

Table-3: Function of PHV as assessed on MDCT

Type(N)	Normal	Dysfunction
Bileaflet valve (St. Jude) (34) Starr Edwards (Ball in cage)(4) Single Disc (1)	10 (29.4%) 3 (75%) 1 (100%)	24 (70.58) 1 (25%) 0

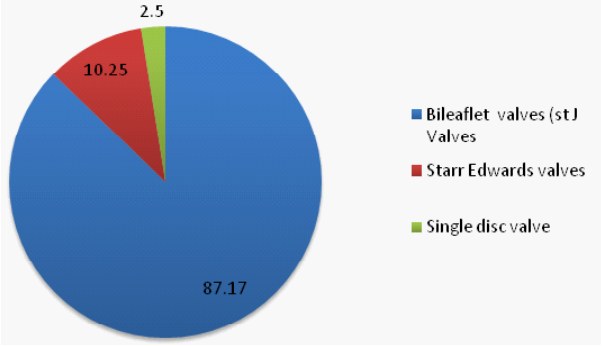


Fig -1: The type of the valves assessed on MDCT.

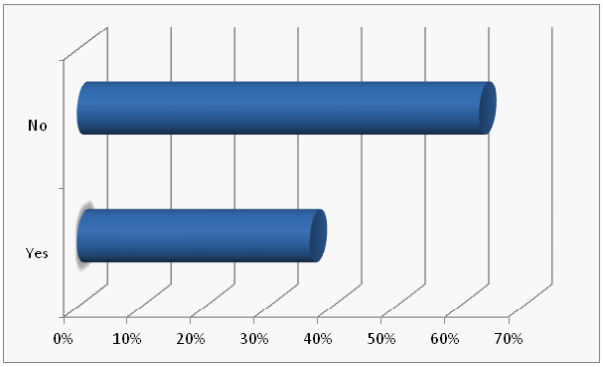
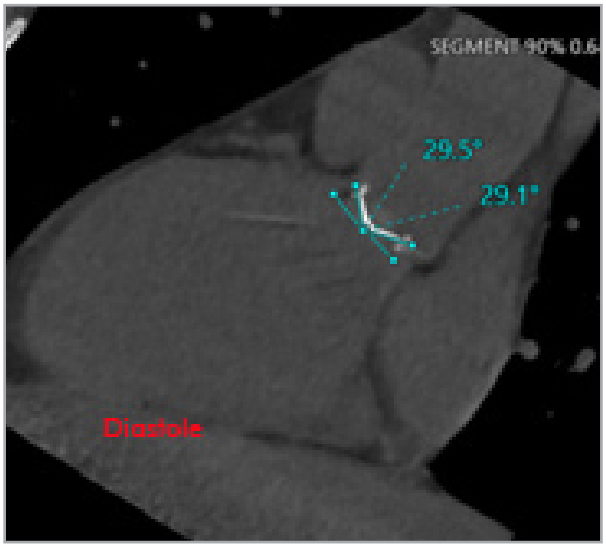
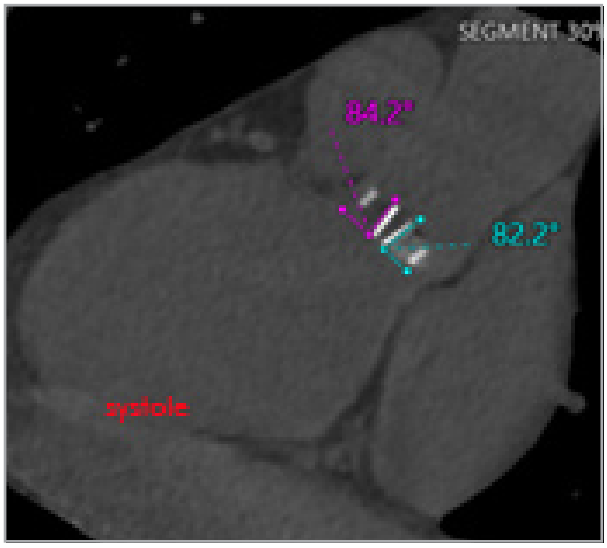
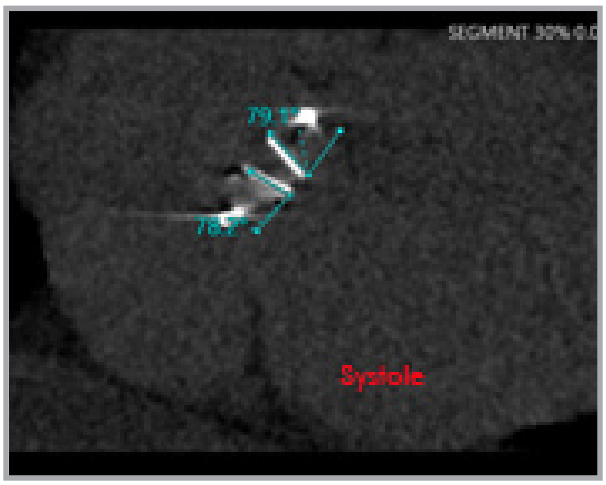


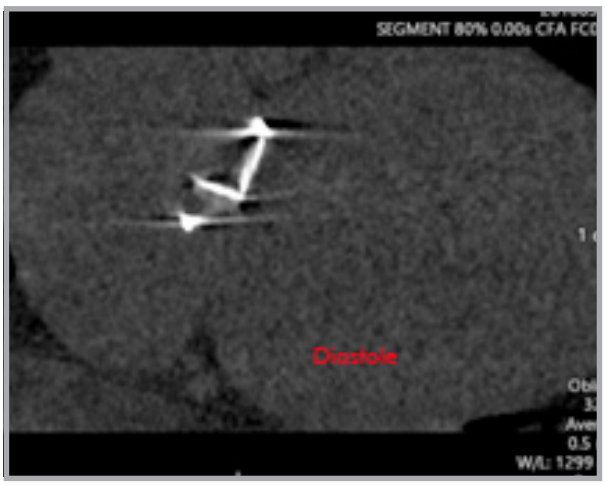
Fig-2: 11(36.6%) patients had fluoroscopy but 19(66.3%) did not.



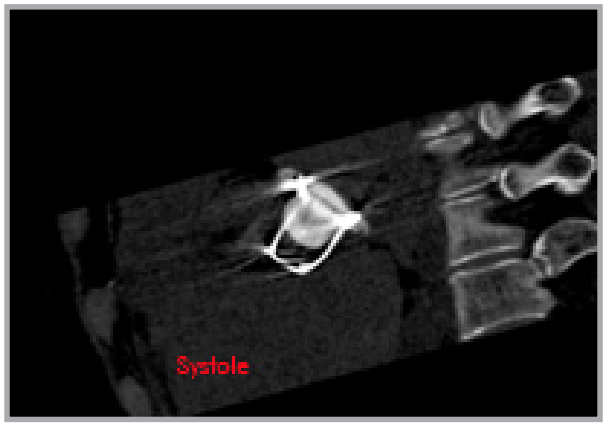


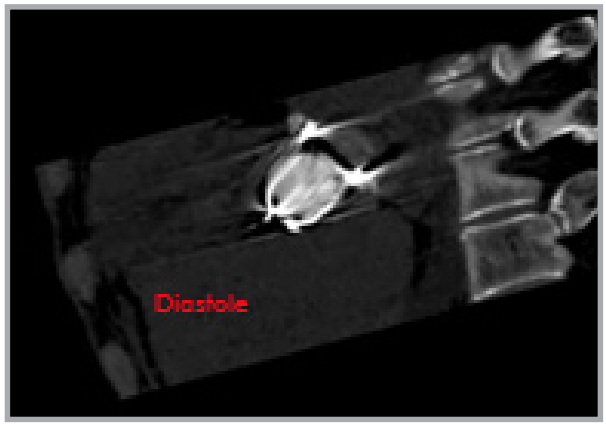
A,B) Plain gated MDCT image of a patient of bi leaflet aortic valve with normal function in systole and diastole.



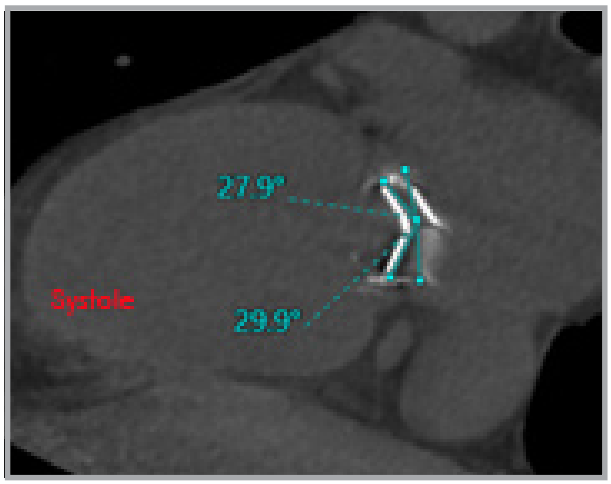


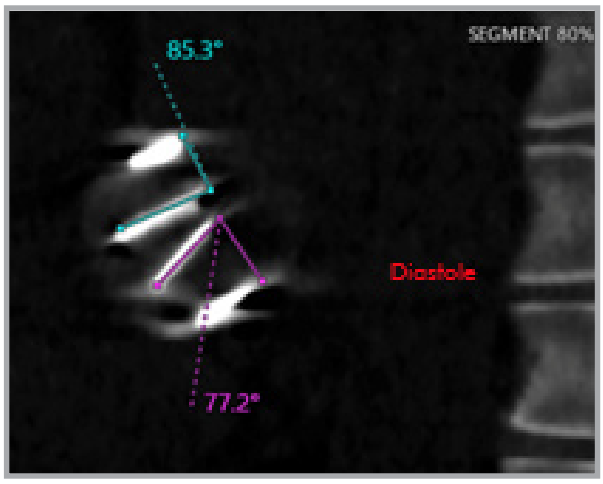
C,D) Plain gated MDCT image of a patient of bi leaflet aortic valve with struck up one disk in diastole and adequet mobility during systole.



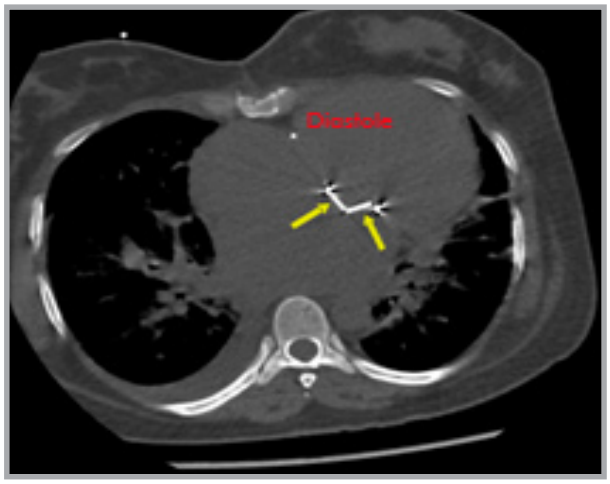


E,F) Plain gated MDCT image of a patient with ball cage (Star Edwards) valve at mitral position with normal function during systole and diastole.





G,H) Plain gated MDCT image of a patient with bi leaflet valve at mitral position with normal function during systole and diastole.



G,H) Plain gated MDCT image of a patient with bi leaflet valve at mitral position with struck up disk during diastole.

thesis. Seven (33.3%) had single disc stuck up 7 (33.33%) patients had both disks stuck up. The mean gradient across obstructed mitral valve was 22.9±4.1mmHg

Four patients had Starr Edwards cage ball prosthetic valve at mitral position only one patient had restricted mobility of the ball signifying the malfunction and three patient has good function of Starr Edwards ball cage valve.

Two patients had metallic bi-leaflet valves at tricuspid position that had stuck up disks with increased mean gradients (13±2.8mmHg)

Figures (A,B,C,D,E,F,G,H) shows the plain gated MDCT images of a prosthetic bi leaflet valves and ball cage valve (Star Edwards) at aortic and mirtal position having mormal function and dysfunction.

DISCUSSION:

Severe valvular dysfunction requires valve replacement, which can be metallic prosthetic valve or tissue valve. Long-term prognosis is dependent on the normal function of the prosthetic metallic valve.[8] The dysfunction of the PHV results in increased morbidity and mortality.[9] Fluoroscopy has been the main stay of diagnosis in prosthetic valve dysfunction. It is noninvasive, readily available. Fluoroscopy needs appropriate projections for identifying the type of valve, to assess the function of the prosthetic valve, mobility of the ring and discs.[10] In this study about eleven (36.6%) patients were referred following difficulty in identifying the exact cause of dysfunction on fluoroscopy. It has been observed that fluoroscopy is appropriate for the aortic valve prosthetic valve dysfunction but has limitations for mitral valve prosthesis. The limitations of Fluoroscopy are that it cannot provide the

hemodynamic data for valve dysfunction.[11] Cardiac CT is not used as routine imaging modality for the evaluation of the normal function of the prosthetic valve. MDCT has been used as a complimentary imaging modality along with TTE, TEE and fluoroscopy for the assessment of complication.[12] The metallic leaflet of the PHV can be assessed on plain gated scan as it is radio opaque and its opening and closing angles can be assessed for the valve function.The data for the plain gated MDCT scan does not require contrast similar to fluoroscopy. PHV function can be analyzed by reconstructing the data of plain gated scan both in systolic phase which is 20-30 % of RR interval and in diastolic phase which is 60-90% of RR interval.

The PHV assessment was done on plain gated MDCT in this study which did not required increased spatial resolution and noise reduction so the radiation dose was much reduced by decreasing the z-coverage and reducing the tube voltage to 80 kv and tube currant to 200 mAs. In the present era lot of cardiovascular imaging is being done for coronary artery disease and non coronary cardiac indications. The range of radiation dose from these imaging procedures is 0.5-30 mSv. The life time risk of radiation from a single cardiovascular imaging from MDCT is very small. [13,14]

TTE is the imaging modality of choice for initial follow up for the assessment of normal function and dysfunction of PHV. It provides the information as regards the site of the valve, type of the valve and function of the valve. In addition it can give information regarding flow and hemodynamic assessment with continuous wave Doppler and colourDoppler.TTE in metallic prosthetic valve causes acoustic shadowing, reverberation and refraction artifact which poses difficulty in its assessment. The left atrial(LA) and right atrial(RA) side of the prosthetic mitral and tricuspid valve is not assessed because of these artifacts on TTE. Dysfunction caused by thrombus, vegetation ,pannus is usually present on the LA or RA side of the valve. This limitation is overcome by the TEE.TEE provides adequate information as regards the thrombus, vegetation and pannus growth on LA or RA side of the prosthetic mitral or tricuspid valve.[15]

LIMITATIONS:

Plain gated scan has adequate capability in analysis of disc mobility, but has limitation to assess the cause of the dysfunction such as thrombus, vegetation, paravalvular leakage, aneurysm which requires contrast administration. The other limitation is it does not provide the flow and hemodynamic data

CONCLUSIONS:

MDCT can be used for the assessment of prosthetic valve dysfunction in patients with suspected valve dysfunction on the basis of increased mean pressure gradient on transthoracic echo alone or in situations where fluoroscopy has limitation in diagnosis.

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