A STUDY ON EVALUATION OF CORONARY ARTERY VARIATIONS USING 64-SLICE MDCT CORONARY ANGIOGRAPHY IN MAHARASHTRA

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Abstract-

Introduction- Coronary artery anomalies (CAA) are the genetic abnormalities which are generally asymptomatic. However, these anomalies can cause chest pain, syncope, arrhythmias, MI (myocardial infarction) or unexpected death. Multidetector row-computed tomography (MDCT) has been introduced as the best modality for coronary imaging. In the current study, we tried to evaluate the CAV including anomalies using 64-Slice MDCT coronary angiography in selected population.

Material and Method- The current study was a cross-sectional and observational in nature, carried out at Biyani Diagnostic Centre, Dhule, Maharashtra from December 2022 to November 2023. A total of 106 patients were included in the study after applying inclusion and exclusion criteria. Philips Brilliance 64-slice MDCT was used for imaging modality. Data were restructured by retrospective gating in end-diastolic phase or end-systolic phase to clearly figure the 'right coronary artery (RCA)'. For evaluation of CAA, CAV and coronary artery stenosis (CAS), the 3D radiological image of complex anatomy of the coronary artery tree was axially projected. CAV was considered based on American Heart Association (AHA) scheme. All the collected data were statistically analyzed by descriptive statistics using Microsoft excel 2010.

Result- The study included 106 patients with age range of 22-74 years and mean age of 52.9±9.5years. in the current study, Right dominance was seen in 90(84.90%), left dominance in 12(11.32%), and co-dominance was observed in 4(3.77%) patients. Smaller branches like conus artery, sinus node artery and septal branches were seen in most of the patients in our study. Type II (partially supplying apex) LAD variation was found to be the commonest among study subjects. As far as coronary anomalies are concerned, it showed prevalence of 15.09% in our study. The most common was the coronary arteries running within the myocardium i.e. myocardial bridging. The present study found 2(1.88%) cases of malignant anomalies.

Conclusion- In the current study, CAV was present in most of the patients. Although, prevalence rate of CAA was found to be 15.09%, with the left coronary artery anomalies to be more common than right coronary artery anomalies. MDCT modality is tremendously helpful in indicating the presence CAV and CAA and it gives complete and exact information about the anatomy of coronary artery. This information can be vital for correct diagnosis and treatment plan of the patients as in case of interventional procedures.

Keywords- Coronary artery, MDCT, Variartion, Anomaly, CAV, CAA etc.

Introduction-

Coronary artery anomalies (CAA) are unusual inherited variations with occurrence of 0.17 or 1.2% depending on the method of evaluation i.e. autopsy or ‘conventional coronary angiography’ (CCA).[1] Coronary artery variations (CAV) can be the reason for severe pain in chest and may even be fatal.[2] Around 20% of CAV cases lead to life-threatening symptoms including syncope, arrhythmias, MI (myocardial infarction) or unexpected death.[3] However, such anomaly or variations are mostly asymptomatic clinically. CAV and CAA are generally used interchangeably as still there is no agreement about the differentiation of these two conditions. Angelini et al.[4] in their study have anticipated that any change from the typical standard anatomy existing in >1% of the residents can be designated as variation and may be called as anomaly if it exists in <1% of the inhabitants. CAV is generally observed in young population and athletes, typically during or after vigorous exercise.[5] CAV is the second most common cause of unexpected cardiac failure in athletes[6] and in USA, it accounts for 11.8% deaths among them. Another study documented that 12% of CAV originated sudden cardiac deaths were associated with sports and 1.2% were associated with non-sports among population varying from 14-40 years age. The information regarding the detail of CAV present in coronary artery disease (CAD) cases is decisive for the cardiologist before conducting any invasive procedure in such patients. So detection of CAV in population is vital and viable.

Earlier CAVs were screened by CCA, which is the gold standard technique for depiction of CAV. Many other procedures have also revealed good results in screening of CAV but the major problem associated with them is their cost, invasiveness and limited availability. Moreover these techniques are believed to be insufficient for large-scale clinical implementation. [7] So, a new imaging technique i.e. ‘Multidetector row-computed tomography (MDCT)’ has been introduced in this field and its medical implementation for coronary imaging is progressively growing. At present time, MDCT is considered as the best modality for 3D visualization of the convoluted anatomy of coronary arteries. Further isotropic spatial resolution and quicker temporal resolution by 64-slice MDCT has made it a choice of modality due to its superior performance than other techniques. Hence it is extremely important to detect and explain the coronary variations on CT coronary angiography. In this regard, our study has aimed to evaluate the CAV using 64-Slice MDCT coronary angiography in selected population.

Material and Method-

The present study was an observational cross-sectional research carried out at Biyani Diagnostic Centre, Dhule, Maharashtra from December 2022 to November 2023. A total of 106 cases with chest pain after exertion, risk factors, changes on electrocardiography (ECG), atypical or typical angina with indecisive stress test and suspected CAD were enrolled in the study after obtaining ethical clearance from Ethics committee and written consent from the participants. Patients having overall poor health status, epilepsy, pregnancy, arrhythmia, hyperthyroidism, contraindication to use of beta-blockers, allergy to contrast agents, renal and respiratory dysfunction were excluded from the study. Before the procedure, pulse rate (PR), blood pressure (BP), serum urea and creatinine concentration of all the participants were measured. The patients, already on beta-blocker therapy due to any reason, were given their regular dose and other cases with heart rate (HR) >75/ minute were given a beta-blocker one hour prior to imaging. The PR was observed after every 30-minute and once HR of the patient reached below 75 beats, then just before the scan, sublingual nitroglycerin was given to them for optimal dilatation of their coronary arteries. Patients were asked to be in supine position and detailed information of the procedure along with instruction of holding the breath when asked was given to them to ensure quality and safety of the scan. A 20G needle was inserted into ante-cubital vein of the right arm and then a testing bolus of 100ml of iso-osmolar non-ionic iodinated contrast agent i.e. contrapaque 350 was infused with a rate of 5ml/sec, followed by a 40ml saline chaser. Monitoring of heart rhythm was done by ECG. Philips Brilliance 64-slice MDCT was used for imaging modality with beam collimation-10mm, detector configuration-64x0.625, pitch-0.16, tube current-350 to 600 mAs, voltage-120kv, total exposure time-6.5s and mean effective radiation dose-17mSv. ROI cursor was placed in left ventricle and bolus-tracking technique was used to manually trigger the image acquisition by synchronization between MDCT and arterial course of contrast. Data were restructured by retrospective gating in end-diastolic phase (-300ms to -450ms prior to peak of the subsequent R wave) or end-systolic phase to clearly image the ‘right coronary artery (RCA)’.

Restructured images at optimal phase were relocated to a different workstation where image analysis was done. For evaluation of CAA, CAV and coronary artery stenosis (CAS), the 3D radiological image of complex anatomy of the coronary artery tree was axially projected. All images were evaluated by a study blinded skilled radiologist and interpreted by jointly considering the post-processing tools like ‘multiplanar reconstruction (MPR), curved planar reformat (CPR), maximum intensity projection (MIP) and 3D volume rendering technique (VRT)’. Image evaluation started from the examination of coronary artery dominance, their origin, pattern of branching, course and area supplied by the major coronary arteries. The deciding factor for coronary artery dominance pattern is the origin of PDA (posterior descending artery) and PLB (postero-lateral branch). PDA and PLB originating from RCA (right coronary artery) were defined as right dominance and from LCMCA (left main coronary artery)/left circumflex artery (LCx) was defined as left dominance. PDA originating from RCA and PLB originating from LCx was defined as co-dominance.[8] CAA were categorized according to Angelini et al.[4] based on their origin, termination, course and intrinsic coronary anomalies. Segments and CAV were considered based on AHA (American Heart Association) scheme.[9]

All the collected data were statistically analyzed by descriptive statistics using Microsoft excel 2010.

Result-

The present study included 106 patients undergoing 64 slice MDCT with age ranged from 22-74 years and mean age of 52.9±9.5years. The study depicted male predominance with 77(72.64%) males and 29(27.36%) females as clearly visible from figure 1. The mean HR of patients was 68.1±8.0/min with range from 55-91 /min.

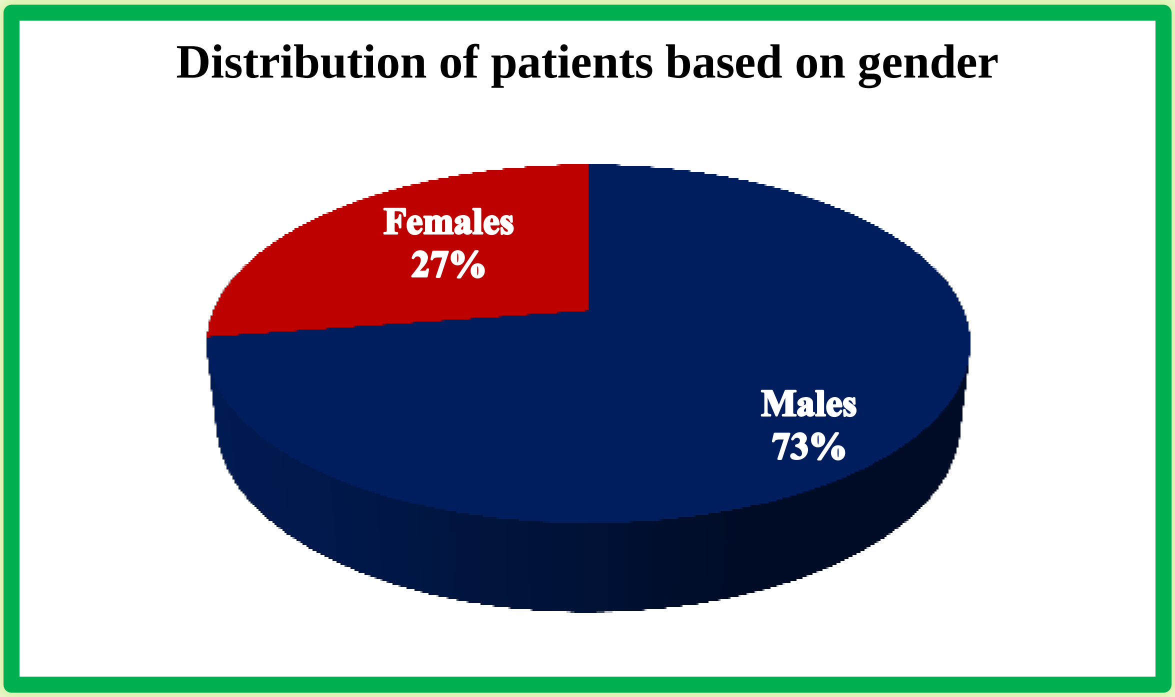

Figure 1- Distribution of patients based on gender

Table 1 and Figure 2-8 show the prevalence and type of different CAV in the study. Right dominance was seen in 90(84.90%), left dominance in 12(11.32%), and co-dominance was observed in 4(3.77%) patients. Further, smaller branches like conus artery, sinus node artery and septal branches were also visualized by MDCT in patients of our study and were seen in 104(98.11%), 101(95.28%) and 97(91.51%) cases respectively. The conus artery in patients mainly originated from proximal RCA i.e. in 71(66.98%), and in rest of the cases it originated from ostial RCA (20, 18.86%) or from the aorta (13, 12.26%). The origination of sinus node artery (SNA) in our study was seen from the 'right coronary artery (RCA)', 'left circumflex artery (LCx)', LCx & RCA, pulmonary artery (PA) & LCx or from aorta in 72(67.92%), 17(16.04%), 10(9.43%), 1(0.94%) and 1(0.94%) respectively. The LMCA trunk in present study depicted a variable length ranged from 18–598 mm with mean of 110±52mm and median of 104mm. The subjects who presented with length of <1cm, 1-2cm and >2cm were 51(48.11%), 48(45.28%) and 7(6.60%) in number respectively. Further the most common variation detected of intermediate artery in distal 'left main coronary artery (LMCA) between 'left anterior descending artery (LAD)' and LCx is the ramus intermedius branch, which was observed in

24(22.64%) patients along with presence of few diagonal branches. Diagonal branches from LAD were noticed in 104(98.11%) and not seen in remaining 2(1.88%) patients. The number of branches seen were presented as 1, 2 or >2 and were visualized in 27(25.47%), 52(49.05%) and 25(23.58%) cases respectively. Marginal branches from LCx were seen in 105(99.05%) caes and not seen in remaining 1(0.94%) case. The number of branches noticed were 1, 2 or >2 seen in 39(36.79%) 48(45.28%) and 18(16.98%) subjects respectively. The LAD variation observed were of type I (not supplying apex), II (partially supplying apex), III (supplying entire apex) or IV (wraps around apex) seen in 27(25.47%), 38(35.84%), 25(23.58%) and 16(15.09%) patients respectively.

Table 1- Type of Coronary artery variations and its prevalence.

Variation		**n (%)**
Conus artery branch from	Proximal RCA	71(66.98%),
	Ostial RCA	20(18.86%)
	Aorta	13(12.26%)
	Not detected	2(1.88%)
Sinus node artery branch from	RCA	72(67.92%)
	LCx	17(16.04%)
	LCx and RCA	10(9.43%)
	PA and LCx	1(0.94%)
	Aorta	1(0.94%)
	Not detected	5(4.71%)
Septal branches from LAD	Detected	97(91.51%)
	Not detected	9(8.49%)
Ramus intermedius branch	Detected	24(22.64%)
	Not detected	82(77.39%)
LMCA length	<1cm	51(48.11%)
	1-2cm	48(45.28%)
	>2cm	7(6.60%)
LAD variation type	I	27(25.47%)
	II	38(35.84%)
	III	25(23.58%)
	IV	16(15.09%)
Diagonal branches from LAD	1	27(25.47%)
	2	52(49.05%)
	>2	25(23.58%)
	Not detected	2(1.88%)
Marginal branches from LCx	1	39(36.79%)
	2	48(45.28%)
	>2	18(16.98%)

	Not detected	1(0.94%)

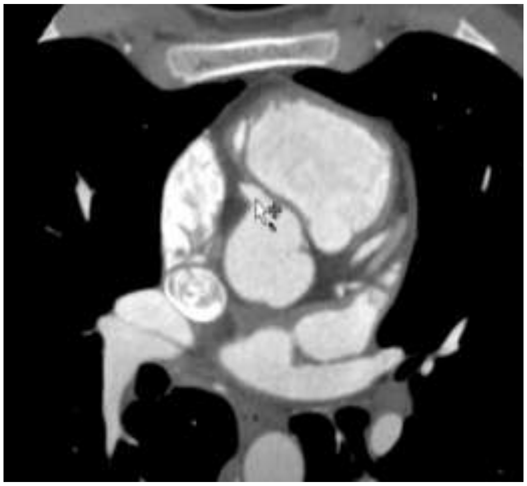

Figure 2- Conus artery branch from Proximal RCA

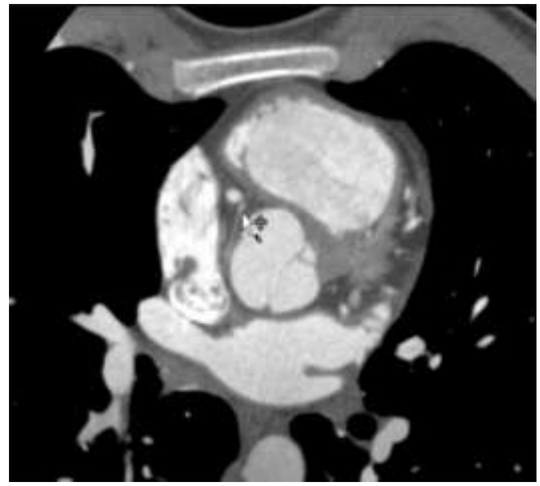

Figure 3- SA Nodal artery branch from RCA

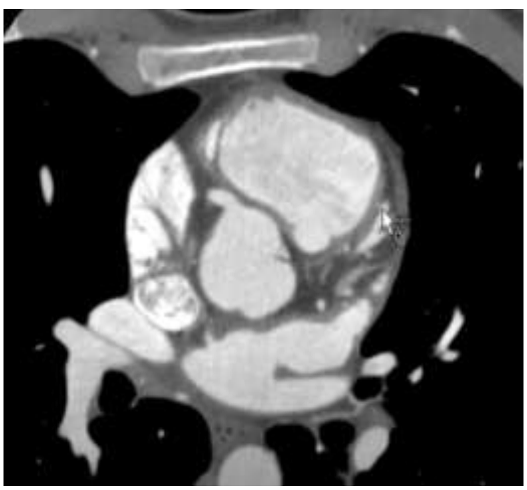

Figure 4- Septal branch from LAD

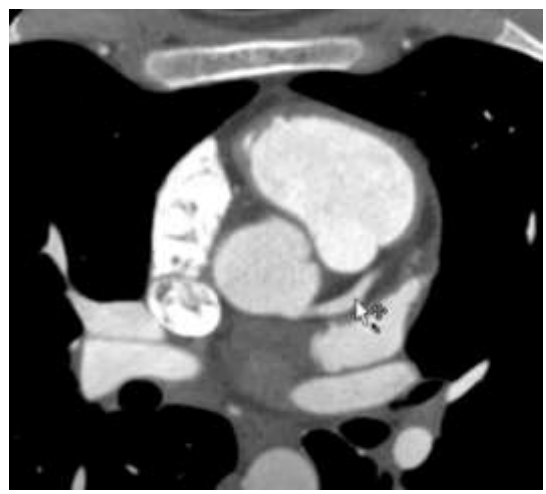

Figure 5- LMCA

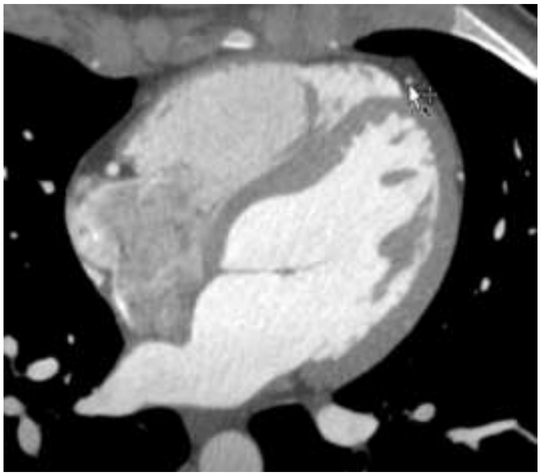

Figure 6- LAD Variation

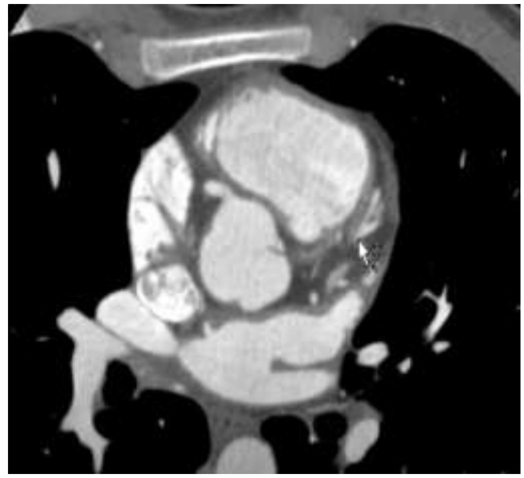

Figure 7- Diagonal branch from LAD

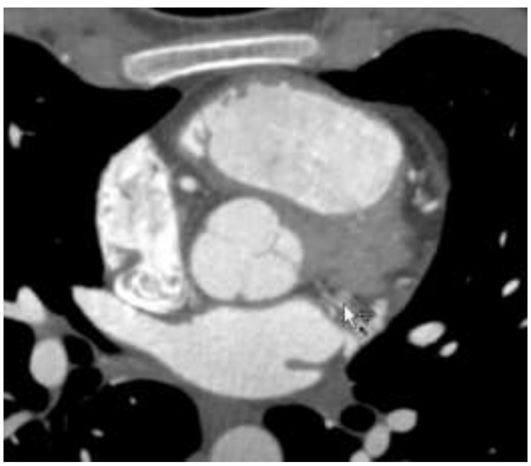

Figure 8- Marginal branch from LCx

As far as coronary anomalies are concerned, they are illustrated in figure 9 and the present study showed prevalence rate of 15.09%. The most common was the coronary arteries running within the myocardium which is called as myocardial bridging. The myocardial bridging was noticed in 13(12.26%) cases. Out of which 12(11.32%) were having superficial myocardial bridging and only 1(0.94%) had deep myocardial bridging. 1(0.94%) subject had no LMCA and due to its absence, LAD and LCx originated from sinus valsalva and inspite of outflows with separate ostia from 'left sinus valsalva' no low or high outflow was noticed. Commissural origination was seen in 2(1.88%) cases and based on this, these anomalies can be additionally categorized into malignant and benign. They are referred as malignant when interarterial course between aorta and PA is observed. Various hypotheses are associated with raised risk of sudden cardiac death in such cases.[10] The present study found 2(1.88%) cases of malignant anomalies. Out of which, in 1(0.94%) patient RCA was seen originating from left coronary sinus and in 1(0.94%) patient, LCx was noticed originating from right coronary sinus.

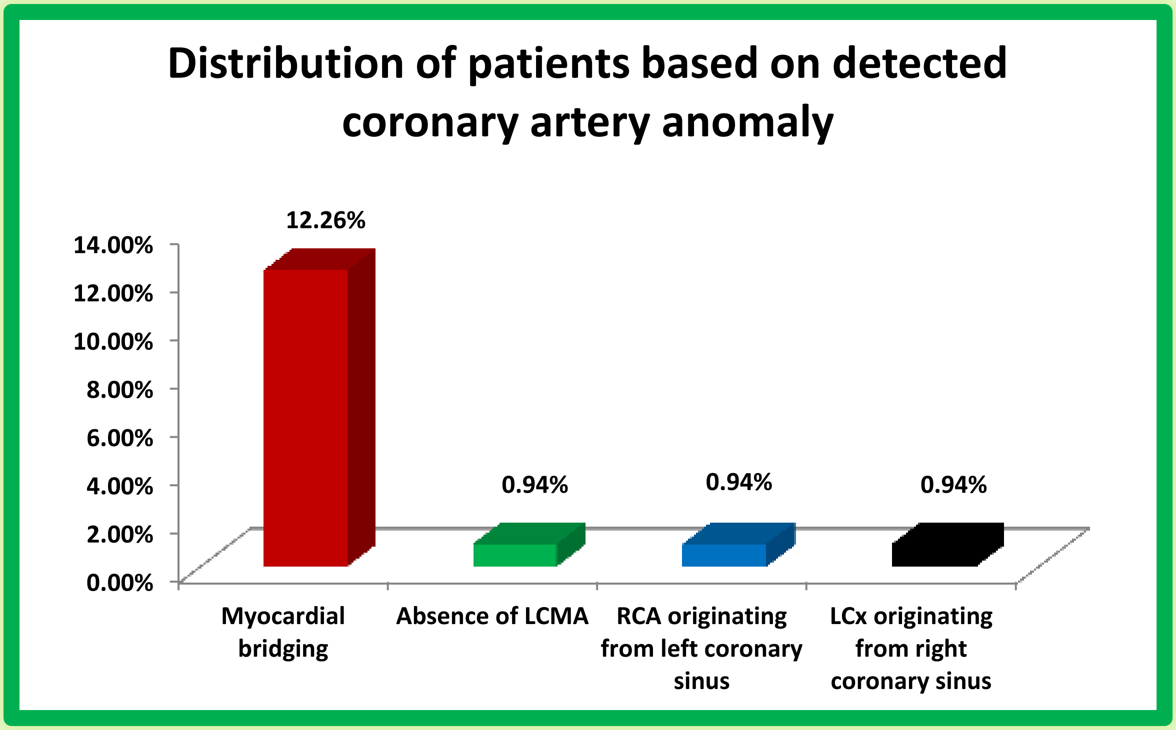

Figure 9- Distribution of patients based on detected coronary artery anomaly

Discussion-

The present study was done at Biyani Diagnostic Centre, Dhule, Maharashtra for a period of 1 year on 106 patients to evaluate CAV using 64-Slice MDCT coronary angiography. The CAV and CAA may exist as early as birth but are generally asymptomatic. They are often accidentally encountered during autopsy or angiography and can lead to technical difficulties at the time of procedure. So, the necessity for correct anatomical structure of the coronary artery tree is significant during angioplasty, due to revascularization reason. CAV and CAA cannot be only considered as an uncommon aspects as they may often result into a related clinical effect. Now a days to detect CAV and CAA, the use of new generation modalities like MDCT has significantly increased because a larger area can be scanned in noticeably lesser duration with remarkable drop in the movement artifacts due to respiratory function. Moreover, high scanning rate combined with raised longitudinal resolution and thin slice thickness allows for better quality of 3D images along with use of less contrasting agents.[11] In present study, mean age was 52.9±9.5years. This finding is in close agreement with the study by A. Rao et al.[12] and Graidis et al.[13] Our study was having male predominance which is supported by A. Rao et al.[12] and Satish Prasad et al.[14] Further the mean HR found in patients of current study is in harmony with the study by Mustafa Kayan et al.[15] The present study depicted right dominance in 90(84.90%), left dominance in 12(11.32%), and co-dominance in 4(3.77%) patients. This outcome is strongly in agreement with the study by Filippo Cademartiri et al.[16] and Ritu Mehta et al.[17] although results by A. Rao et al.[12] and Mustafa Kayan et al.[15] are in contrast to our study as they found much higher co-dominance than our study. The raised co-dominance incidence of coronary arteries could be due to no clear consensus on co- dominance. The conus artery may not just be formed from RCA. In addition, it can also originate from right sinus valsalva via a different orifice.[18] In our study the conus artery mainly originated from proximal RCA followed by ostial RCA and aorta. This finding is in concordance with the study by A. Rao et al.[12] and Filippo Cademartiri et al.[16] The previous studies in contrast to our study may be due to difference in race and geographical area. The SNA in our study mainly originated from RCA followed by LCx artery and this pattern is in harmony with other literature.[15] Another studies by A. Rao et al.[12] and Filippo Cademartiri et al.[16] also strongly supported our study. Further ramus intermedius branch is one of the most common variation detected with occurence rate of 22.64% which is much lower than the previous studies with 33% prevalence.[19,20] Although findings of study by A. Rao et al.[12] and Filippo Cademartiri et al.[16] supported the current study. Another study by Ali Mahir Gündüz[21] reported lower incidence of intermediate branch than our study However, the necessity for reporting this variation is due to the association of its presence with reduced number of diagonal branches. The LMCA length is from 0.5-2cm and in current study maximum patients had length <1cm followed by 1-2cm and our outcomes agreed with the Cademartiri et al.[22] Furthermore LAD variation has four types and the most common in the present study was type II and this is in harmony with the study by Ritu Mehta et al.[17] Mostly patients of our study depicted two diagonal branches from LAD and two marginal branches from LCx and this outcome is also in concordance with studies by A. Rao et al.[12] and Filippo Cademartiri et al.[16]

As far as CAA are concerned, the present study showed prevalence rate of 15.09% which is lower than the study by Filippo Cademartiri et al.[16] and other studies and the reason could be the small sample size or the idea of inclusion criteria to include only symptomatic patients. However the incidence is much higher compared to study by A. Rao et al.[12] and study by Angelini et al.[4] This could be due to superior quality of 3D imaging modality used in our study. Probably due to small sample size, myocardial bridging in present study was noticed in only 12.26% cases. However usual reported rate is 30% in other studies.[12,15] However, study by Ali Mahir Gündüz[21] is in agreement to our findings. Generally nonexistence of LMCA has no harmful effect on the body hemodynamics but poor knowledge about this leads to possibility of misdiagnosis[23] and can lead to some procedural difficulty. The incidence of nonexistence of LMCA in present study is nearly comparable to previous studies (0.41-0.52%).[24,25] Although it was much lower than findings by Cademartiri et al.[22] with occurrence rate of 3.3%. The present study showed 0.94% incidence rate of RCA originating from left coronary sinus which is nearly in harmony with the literature.[14]

Conclusion-

The present study was done to evaluate CAV using 64-Slice MDCT coronary angiography. In the current study, CAV was present in most of the patients. Although, prevalence rate of CAA was found to be 15.09%, with the left coronary artery anomalies to be more common than right coronary artery anomalies. MDCT modality is tremendously helpful in indicating the presence CAV and CAA. Due to high spatial and temporal resolution of MDCT, it gives complete and exact information about the anatomy of coronary artery. This information can be vital for correct diagnosis and treatment plan of the patients as in case of interventional procedures. This method accurately describes the origin and course of CAA and CAV and has turned out to be the reference method in assessing CAV and CAA. So if the patient is asymptomatic or symptomatic, the MDCT is the paramount for radiologists to detect and differentiate such variations, anomalies and their related clinical significance.

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Conflicts of interest: None

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