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Coronary Artery Anomalies

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DETECTION OF CORONARY ARTERY ANAMOLIES AND VARIANTS USING CORONARY COMPUTED TOMOGRAPHY ANGIOGRAPHY

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ABSTRACT

Objective: To determine the frequency of Coronary artery anomalies using coronary CT angiography.

Study Design: Cross sectional study.

Place and Duration of Study: Armed Forces Institute of Cardiology and National Institute of Heart Diseases (AFIC/NIHD), from Aug 2014 to Apr 2015.

Methodology: After fulfilling ethical criteria, all consecutive patients of either gender who were referred for CCTA were included. CCTA was carried out using a 64-MSCT scanner after IV injection of non-ionic contrast mediums. The scan field was extended from the proximal aorta to the cardiac apex. Retrospective ECG-gated images were obtained. Both coronary arteries were evaluated at different phases of cardiac cycle.

Results: Our data shows that mean age as 51.19 ± 12.47 years, 982 (80.89%) male and 232 (19.11%) females, frequency of coronary anomalies were 89 (7.33%). Muscle bridging in mid-course and distal segment of LAD were the most common type.

Conclusion: The frequency of Coronary artery anomalies is higher in patients undergoing CTCA for any indication. However, it is required that every patient undergoing CTCA should also be screened for coronary artery anomaly. Some other studies in local population are also required to validate our findings.

Keywords: Coronary artery anomalies, Coronary CT angiography, Frequency.

INTRODUCTION

Knowledge of physiology, normal and variant anatomy and anomalies of coronary circulation is progressively vital component in managing congenital and acquired heart diseases. Congenital, inflammatory, metabolic or degenerative diseases may involve coronary circulation gradually and complex cardiac surgical repairs demand enhanced understanding to improve operative outcomes.

The Latin term corona, or crown, aptly describes coronary arteries that supply cardiac parenchyma with nutrient blood flow. Coronary arteries (most often 2) are normally the only vessels arising immediately above the free margin of aortic valve from the ascending aorta. The name and nature of a coronary artery or branch is defined by that vessel's distal vascularization pattern or territory, rather than by its origin.

The right coronary artery (RCA) most commonly arises separately from an ostium just below the sinotubular junction of the right (right anterior) sinus of Valsalva (sinuses on either side of the point of aortic and pulmonary commissural contact). The RCA courses in the right atrioventricular groove and provides nutrient branches to the right ventricular free wall, extending to the acute margin of the heart. The first branch arising from the RCA is the conal or infundibular branch, which courses anteriorly to supply the muscular right ventricular outflow tract or infundibulum. The RCA supplies blood to the atria with a highly variable pattern of small branches. The sinus node artery arises from the proximal RCA in approximately 50% of patients. The distal extent of the RCA varies and may extend posteriorly as far as the obtuse margin of the heart[1].

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In 90% of patients, the RCA supplies the posterior descending coronary artery branch at the crux of the heart, which supplies the atrioventricular (AV) node and the posterior aspect of the interventricular septum.

The left coronary ostium is usually single, arises from the mid position of the left (left anterior) sinus of Valsalva just above the level of the free margin of the aortic valve leaflet and generally below the sinotubular junction. It gives rise to a short, common LMCA that branches into the left anterior descending (LAD) and left circumflex (LCx) coronary arteries. The LAD courses in the anterior interventricular groove, giving rise to the anterior septal perforating branches as it extends toward the cardiac apex[1]. Diagonal branches arise from the LAD and course at downward angles to supply the anterolateral free wall of the left ventricle.

The LCx coronary artery courses along the left AV groove, around the obtuse margin, and posteriorly toward the crux of the heart. Should the LCx coronary reach the crux of the heart and supply the posterior descending coronary artery, the left coronary system would be termed dominant. This occurs in approximately 10% of patients. Atrial branches may arise from the LCx coronary artery and supply the sinus node in 40% of patients. Obtuse marginal branches arise from the LCx system to supply the posterolateral aspect of the left ventricle. In an estimated 70% of patients, a coronary branch (termed ramus medianus, intermedius, or intermediate branch) arises early off the left coronary system to supply an area between diagonal branches from the LAD and obtuse branches from the LCx systems.

Deviations from normal coronary anatomy are termed as variants or coronary artery anomalies (CAA). It has been proposed that a normal variant refers to an alternative coronary pattern that is relatively infrequent compared to normal, but is seen in more than 1% of the population; in contrast to an anomaly that is seen in less than 1% of otherwise normal individuals[1-3].

METHODOLOGY

The objective of the study was to determine the frequency of Coronary artery anomalies and variants using CT coronary angiography (CTCA). Deviations from normal anatomy are termed as variants or coronary artery anomalies (CAA). For the purpose of classification both anomalies and variants were collectively grouped under the term "anomalies". The CAAs are divided into 4 main groups:

1. **Myocardial bridging:** In this anomaly, a portion of the coronary artery that is normally epicardial, traverses through the myocardium, known as myocardial bridge, and the portion of artery itself is called a tunneled segment.
2. **Anomalies of origin and distribution of Left main coronary artery (LMCA), Left anterior descending artery (LAD) and Left circumflex artery (LCx):**

a. Absent LMCA: LMCA is absent and LAD and LCx arise directly from coronary sinuses resulting in three coronary ostia instead of two.

b. Origin of LMCA from right sinus of valsalva (RSV): Right coronary sinus gives origin to LMCA and RCA.

c. Acute angulation of origin of LMCA: This refers to a slit like or tangential origin of LMCA from the aortic wall (which is normally perpendicular) resulting in restriction of coronary arterial flow.

d. Absent left circumflex artery:A completely absent LCx artery is associated with multiple enlarged diagonal branches of the LAD to supply the lateral wall of the left ventricle and also dominant RCA with its posterolateral branch continuing into the territory of the LCx.

e. Origin of LCx artery from RSV: Anomalous origin of the left circumflex coronary artery from the right sinus of Valsalva.

f. Rudimentary left anterior descending artery (LAD): This implies to a condition in which

there is partial or complete absence of LAD with branches from RCA and LCx supplying the LAD territory.

3. **Anomalies of origin and distribution of right coronary artery (RCA):**

a. Origin of RCA from opposite sinus of valsalva: In this anomaly RCA arises from either the left coronary sinus or non coronary sinus.

b. Acute angulation of origin of RCA:This refers to a slit like origin of RCA from the aortic wall (which is normally perpendicular), resulting in restriction of coronary arterial flow.

4. **Others**

Any variant or anomaly other than above mentioned detected in this study was referred to as others.

It was a cross sectional study, carried out in Armed Forces Institute of Cardiology and National Institute of Heart Diseases (AFIC/ NIHD), Rawalpindi, from 1st August 2014 to 17th April 2015. The Sample size of 1214 was calculated by using WHO sample size calculator taking, Confidence Level: 95%, Anticipated population proportion p:1.25%[4], Absolute precision required: 0.00625. Approval of the ethical committee of the institute was obtained at the beginning of study. Informed consent was taken from all the patients. Consecutive sampling technique was used. Patients of both genders and having age >18 years visiting our departments for coronary CT angiography for any indication were included in this study. Patients with severe arrhythmia, previous serious allergic reaction to the contrast medium, pregnancy, renal and respiratory failure were excluded from study.

The indications for CTCA included the presence of chest pain, abnormal or inconclusive exercise tolerance test, the presence of ischemia on non-invasive tests, coronary artery disease screenings and the determination of patency of bypass grafts or stents.

Patients were given a 50 to 100 mg oral dose of metoprolol one hour prior to the scan, with additional intravenous (IV) metoprolol or intravenous verapamil (in case of asthmatics) administered immediately prior to the scan if necessary. The target heart rate (HR) had less than 80 beats per minute, and procedure was done under close cardiac monitoring for heart rate and blood pressure. All patients received sublingual isosorbidedinitrate immediately prior to starting the scan protocol. CTCA was carried out using a 64-MSCT scanner (Seimens-somatom definition, syngo software, Germany) after IV injection of 80 ml of non-ionic contrast medium (Iopamiro 370; Bracco, Milan, Italy or Iopamidol 370, Bayer sharing Pharma AG, Berlin, Germany) as a bolus dose at a rate of 5 ml/s with retrospective ECG gating. The scan field was extended from the proximal aorta to the cardiac apex.

The imaging parameters were as follows: detector collimation of 64 × 0.625 mm, tube voltage 120 kV, current 500-800 mA, gantry rotation time 330 ms, pitch 0.30, and slice thickness 0.625 mm. Retrospective ECG-gated images were obtained during one held breath. These images were evaluated with multiplanar reconstruction, maximum-intensity projection and three dimensional volume-rendering methods. The 75% phase dur-ing diastole was found to be optimal for the analysis of anomalies of the left coronary arteries. The RCA was evaluated at either the 45% or 80% phase of the cardiac cycle, depending on which phase presented the least amount of motion.

The data regarding age, gender, weight, BMI, indication for coronary angiography and Coronary Anomalies/Variants were recorded. Descriptive statistics were used to calculate mean and standard deviation for Quantitative Variables including age, weight and BMI. Frequencies with percentages were presented for Qualitative variables like gender, indication for coronary angiography, Coronary Anomalies/Variants and Type of Coronary Anomalies/Variants.

RESULTS

A total of 1214 cases fulfilling the inclusion /exclusion criteria were enrolled to determine the frequency of Coronary artery anomalies and variants using CTCA.

Age distribution of the patients was done showing that 610 (50.25%) were between 18-50 years while 604 (49.75%) were between 51-90 years of age, mean ± SD was calculated as 51.19 ± 12.47 years (table-I). Gender distribution showed that 982 (80.89%) were male while 232 (19.11%) were females. Mean weight of the patients was calculated as 77.87± 11.28 kgs. Mean BMI of the patients was calculated as 34.58 ± 5.24. Frequency of coronary artery anomalies/variants was recorded as 89 (7.33%) while 1125 (92.67%) had no coronary artery anomalies (table-III).

CTCA was done in 319 (26.28%) patients with stable angina, 326 (26.85%) patients with acute coronary syndrome, 117 (9.64%) patients with abnormal/Inconclusive ETT, 265 (21.83%) patients fordetection of patency of bypass grafts or stents and 187 (15.40%) patients with Adult Congenital/Valvular heart disease (table-II).

Table-I: Age distribution (n=1214).

Age (in months)	No. of patients	Percentage
18-50	610	50.25
51-90	604	49.75
Total	1214	100
Mean ± SD	51.19 ± 12.47	

Table-II: Frequency of indication for coronary angiography (n=1214).

Indication for coronary angiography	No. of patients	Percentage
Stable angina	319	26.28
Acute coronary syndrome	326	26.85
Abnormal/Inconclusive ETT	117	9.64
For patency of bypass grafts or stents	265	21.83
Adult Congenital/Valvular heart disease	187	15.40
Total	1214	100

Table-III: Frequency of type of coronary anomalies / variants (n=89).

Type of Coronary Anomalies/Variants	No. of patients	Percentage
Muscle bridging in mid-course of LAD	36	40.46
Muscle bridging in distal segment of LAD	35	39.33
Muscle bridging in whole course of LAD	2	2.24
Origin of LCx from right coronary sinus	9	10.12
Origin of LAD from Right coronary sinus	1	1.12
Origin of RCA from Left Coronary sinus	2	2.24
Aberrant High origin of RCA	3	3.37
Absent LMCA (Separate origin of LAD and LCX)	1	1.12
Total	89	100

DISCUSSION

Coronary artery anomalies (CAAs) are congenital alterations in the origin, course or structure of the epicardial coronary arteries. This study was aimed with the view to detect the frequency of various CAAs and variants in patients who underwent CCTA for various indications in our population.

Our data showed that the frequency of coronary anomalies/variants is 89 (7.33%), muscle bridging in mid-course of LAD and Muscle bridging in distal segment of LAD were the most common type of anomalies.

The findings of our study are in agreement with a previous study recorded that the most common type of coronary artery variant is myocardial bridging found in 21.3% cases[4]. Left

main coronary artery (LMCA) and its branches LAD and LCx together accounts for 1.4%[4] of the total anomalies, whereas RCA anomalies occur in 1.25% cases[4].

Previous studies reveal that the true incidence of CAAs in the general population has yet to be determined, published series reporting very different percentages. Alexander and Griffith[5] found an incidence of 0.3% in 1956, based on autopsy studies. In 1993, Cieslinski *et al*[6] recorded the incidence of 0.97% in 4016 subjects undergoing angiography during 1985 and 1989. However, these findings do not reflect the factual frequency of CAAs in general population, since autopsy studies are not performed as a matter of routine practice but for legal issues, the angiography was performed in a selected group of subjects in the latter study.

Angelini and others[7], in 2002, recorded an incidence in approximately 1% of the general population, while a previous prospective study by the same author of 1950 cases undergoing CTCA recorded the incidence of 5.64%[8], much higher than in previous studies but near to our study.

Filippo Cademartiri and others[9-10] assessed the prevalence of variants and anomalies of the coronary artery tree in subjects who underwent 64-slice CTCA for suspected or known coronary artery disease cases and recorded that single or associated coronary anomaly was found in 18.4% of the subjects, with the following distribution: 43 anomalies of origin and course, 68 intrinsic anomalies (59 myocardial bridging, nine aneurysms), three fistulas. They concluded that 64-slice CTCA provides optimal visualization of the variable and complex anatomy of coronary arteries because of the improved isotropic spatial resolution and flexible post-processing tool while in our study CTCA was carried out using a 64-MSCT scanner (Seimens-somatom definition, syngo software, Germany) after IV injection of 80 ml of non-ionic contrast medium (Iopamiro 370; Bracco, Milan, Italy or Iopamidol 370, Bayer sharing Pharma AG, Berlin, Germany) as a bolus dose at a rate of 5 ml/s with retrospective ECG gating.

Other study 11-13 showed, of the 2572 patients, sixty (2.33%) were diagnosed with CAAs, with a mean age of 53.6 ± 11.8 years (range 29–80 years). High take-off of the RCA was seen in 16 patients (0.62%), of the LMCA in 2 patients (0.08 %) and both of them in 2 patients (0.08%). Separate origin of the LAD andLCx from left sinus of Valsalva (LSV) was found in 15 patients (an incidence of 0.58 %). In 9 patients (0.35%) the RCA arose from the opposite sinus of Valsalva with a separate ostium. In 6 patients (0.23%) an abnormal origin of LCx from the right sinus of Valsalva (RSV) was found with a further posterior course within the atrioventricular groove. A single coronary artery was seen in 3 patients (0.12%). It originated from the RSV in one patient and from LSV in two patients. In two other patients (0.08%) the left coronary trunk originated from the RSV with separate ostium from the RCA. LCx artery originating from the pulmonary artery was found in one patient (0.04%). A coronary artery fistula, which is a termination anomaly, was detected in 4 patients (0.15%). However, in our study the frequency of coronary anomaly was higher than this study while Muscle bridging in mid-course of LAD, Muscle bridging in distal segment of LAD, Muscle bridging in whole course of LAD and Origin of LCx from right coronary sinus were the commonest type of coronary artery anomaly, the difference in type of anomaly may be due to demographic difference between our population and the above study.

Other recent studies[14-18] determined the prevalence of coronary anomalies using CTCA and evaluated the relationship between coronary artery anomalies and chest pain. Coronary anomalies were found in 176 patients (1.39%) at their institute. Anomalies of origination, course, and termination were detected in 118 (0.93%), 28 (0.22%), and 30 (0.24%) patients, respectively. After the exclusion of 32 patients with combined heart disease, typical 16 (11.1%) or atypical 28 (19.4%) chest pain was present in 44 (30.6%) of the 144 patients at the time of diagnosis. The

frequency of CAA was lower than our study. The difference may be due to the fact that they enrolled the cases with chest pain only.

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CONCLUSION

The frequency of Coronary artery anomalies is higher in patients undergoing CTCA for any indication. It is suggested that every patient undergoing CT angiography should also be screened for coronary artery anomaly. Some other studies are also required to validate our findings.

CONFLICT OF INTEREST

This study has no conflict of interest to bedeclare by any author.

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