ORIGINAL RESEARCH PAPER

Radiodiagnosis

C.T. CORONARY ANGIOGRAPHY IN SUSPECTED CORONARY ARTERY DISEASE- A STUDY ON 100 PATIENTS BY CALCIUM SCORING AND CTCA.

KEY WORDS:

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ABSTRACT

Computed Tomography Coronary Angiography (CTCA) is an effective non-invasive modality to visualize coronary artery disease and the presence of luminal and vessel wall pathology. It is an effective tool for diagnosing patients at risk of coronary artery disease.

Due to the continuous motion of the beating heart, its cross sectional imaging has always been technically challenging. Some of the challenges in evaluating the coronary arteries at Computed Tomography (CT) are - small size of the vessels and their close vicinity to the moving heart. The present study was undertaken to determine the role of Coronary CT Angiography in patients with suspected coronary artery disease. There were 100 suspected cases of Coronary Artery Disease evaluated by Non Contrast Calcium scoring followed by CTCA.

Introduction

Coronary artery disease (CAD) is a one of the leading causes of mortality and morbidity all over the world.

Pharmaceutical therapy, surgical revascularization or percutaneous balloon angioplasty with stenting are mainstay of therapeutic options for coronary heart disease. It is absolutely necessary to evaluate the coronary artery luminal status to decide whether to institute these therapies or not.

Presently, Coronary Angiography (CA) is regarded as the ''Gold standard'' for the assessment of coronary artery disease and anatomy due to its supreme temporal and spatial resolution. It is known to provide accurate, reliable, and reproducible evaluation of coronary artery lumen for narrowing, stenosis, and occlusion. It also provides the option of directly performing interventional procedure if required.

Even though it is still the gold standard method of evaluating CAD, Conventional Coronary Angiography has few limitations. It is an expensive and invasive imaging modality; and has an overall complication rate for adult procedures at 7.4/1000, with the mortality of 0.7/1000.[5] It offers information only about the site and degree of luminal narrowing and does not provide data on the extent of atherosclerotic changes within the vessel wall, which may be a precursor to luminal pathology in the future.

Exercise treadmill testing (ETT) or Treadmill Test (TMT) is presently one of the initial non-invasive tests for identifying Coronary artery disease among patients with suspected stable ischemic heart disease who are able to exercise with an interpretable electrocardiogram.[6] It is a relatively inexpensive and widely available test. However ETT is limited in its diagnostic accuracy in identifying coronary artery disease and does not localize the site or extent of coronary artery pathology.[7] ETT is also potentially unsafe in patients with possible unstable angina and has lower diagnostic value in patients who cannot achieve an adequate exercise workload [8]. Hence, the role of ETT as the initial imaging modality in patients with suspected CAD is under challenge.

Computed Tomography Coronary Angiography (CTCA) is an effective non-invasive modality to visualize coronary artery disease and the presence of luminal and vessel wall pathology. It is an effective tool for diagnosing patients at risk of coronary artery disease.

Due to the continuous motion of the beating heart, its cross sectional imaging has always been technically challenging. Some of the challenges in evaluating the coronary arteries at Computed Tomography (CT) are - small size of the vessels and their close vicinity to the moving heart. The coronary vessels are typically 2–4 mm in diameter and are parallel, oblique, or perpendicular to the axial plane in portions along its entire course. In addition, they are adjacent to both the atria and ventricles and therefore may be affected by cardiac motion in different phases of the cardiac cycle.

For the optimal visualization of the coronary arteries, the technical factors needed are - a slow heart rate, a short scanning time, sub-centimetric spatial resolution and high temporal resolution. High spatial resolution is needed to evaluate the coronary lumen of small but clinically important branches and the even smaller coronary vessel wall. High temporal resolution is required to limit motion artifacts related to displacement of the coronary arteries during the contraction of the heart.

In order to overcome these limitations, possible solutions are- imaging on CT scanners with high number of detectors per rows (at least 64), faster rotation speeds ($^{1}/_{3}^{rd}$ sec or lower) and reconstructing multiple sets of images obtained in different phases of the cardiac cycle from a volume acquisition.

Cardiac CT imaging moved into the diagnostic realm by the introduction of multi-detector row CT (MDCT) [9,10] and development of ECG-Synchronized scanning and reconstruction techniques known as ECG Gating techniques.[11]

Non-invasive coronary imaging requires a CT system capable of acquiring motion-free, high-resolution images covering the entire heart in a single breath hold. The current generation 64-detector row CT systems and more recently introduced CT scanners with 128-, 256- and 320-detector rows fulfill these requirements.

Increasing the number of detector rows in successive scanner generations increased the volume coverage per gantry rotation and therefore reduces the scan duration (approximately 25 secs with 16 slice scanners, 10 secs with 64 slice scanners, and <1 sec with the recent 320 slice scanners), making it easier for the patients to hold their breath during image acquisition. The ability to scan the entire heart within one heart beat with 256 and 320 slice scanners makes Coronary CT Angiography (CCTA) possible even in patients with arrhythmias. [12–14]

Materials And Methods

This was an observational prospective study conducted in Department of Radiodiagnosis, G.R. Medical College and J.A. Group of Hospitals, Gwalior from May 2016 to September 2017.

Following clinical data were recorded for each patient-

- Age, Sex
- Height, Weight and BMI
- Detailed clinical history with presenting symptoms like chest pain, palpitations, dizziness, headache, etc.

- Duration of symptoms
- History of smoking
- Other systemic diseases like Diabetes mellitus, hypertension, Dyslipidemia
- Any previous history of heart disease
- History of stress/ anxiety if present
- Family history of Coronary artery disease
- Drug history.

INCLUSION CRITERIA:
All suspected cases of coronary artery diseases patient referred to Dept of diagnosis GR Medical College for CT coronary angiography irrespective of age and sex.

EXCLUSION CRITERIA:
All the patients in whom CT CORONARY ANGIOGRAPHY is contraindicated due to any reason:
- Known allergy to contrast agent.
- Renal insufficiency
- Pregnant females
- Hyperthyroidism
- Patients not willing to participate in the study

STATISTICAL ANALYSIS
All the data collected were computed using MS-Excel (2010) and descriptive statistics were analyzed using the same. All the statistical analysis were done using MedCalc ® v12.5 for windows statistical software.

RESULTS
A total of 100 patients were included in the study.
Out of these 100 patients 74 were male & 26 were female.

The youngest subject in the study was 22 years old & oldest was 80 years old.

Maximum no of subjects was in age group 50-59 years .(26%)

The mean age of study group was 47.16 +/- 12.997 yrs (SD)

Out of the 100 subjects, 27 males (27%) in our study were smokers. None of the females in our study were smokers.

29 subjects (29%) were known diabetics, out of which 22 (75.86%) were males and 7 were females(24.14%).

Hypertension was the most common modifiable risk factor in our study. 38 subjects were known hypertensives. 30 of them were males (78.95%) and 8 were females (21.05%)

Hyperlipidemia was present in 31(31%) of the subjects.
History of stress/anxiety was found in 33 subjects, out of which 23 were males (69.7%) and 10 were females (30.3%).

Positive family history of Coronary artery disease was present in 38 subjects (38%)

Out of the 24 CTCA positive cases, 9 males (37.5 %) in our study were smokers.

In the CTCA positive cases, Hyperlipidemia was the most common modifiable risk factor found in 17 cases (70.83%). 15 of them were males (88.24%) and 2 were females (11.76 %).

Hypertension was present in 14 (58.33%) of the cases. 12 of them were males (85.71 %) and 2were female (14.29 %)

11 of the CTCA positive cases (45.83%) were known diabetics, out of which 9 (81.82%) were males and 2 were females (18.18%).

History of stress/anxiety was found in 3cases (12.5%) , out of which 2 were males (66.7%) and 1 was females (33.3%).

Positive family history of Coronary artery disease was present in 12 CTCA positive cases (50%)

None of the studied subjects in our study were underweight.

42% of the subjects belonged to the normal BMI category (18.5 to 22.9 Kg/m^2).

26% subjects belonged to the overweight category , 80.77% of them being males.

The Obese I category (25-29.9 Kg/m^2) comprised of 29% subjects. Out of these 79.3% were males.

Only 3% of total subjects belonged to Obese II category (>30 Kg/m^2).

DISCUSSION
The present study was undertaken to evaluate the role of CT Coronary Angiography in suspected cases of coronary artery disease in the Department of Radiodiagnosis, Gajra Raja Medical College, Gwalior, Madhya Pradesh . A total of 100 patients who had symptoms and/or risk factors indicative of coronary artery disease referred to the Department of Radiodiagnosis, were included in the study. Symptoms, blood investigations & other significant history of the patient were taken. All the 100 patients underwent Coronary Calcium scoring followed by Coronary CT Angiography with prospective ECG Gating.

Age
The mean age of study group was **47.16 +/- 12.997 yrs** in our study which correlates with the study done by **Blankstein R**. ***et al***[145](mean age 51 years) and **Michael Cheezum *et al*** (mean age 54 years)[6] . The most common age group involved was between 50-59 years (26%) which correlates with study done by **Rajneesh Madhok et al**[144].In that study, the highest number of the patients were in the age group of 51-60 years (44%). The youngest patient in our study was **22 years** old & oldest was **80 years** old.

Gender
In the present study we included patients of both gender & there was male predominance (74%) as compared to female (26%).The male to female ratio was 2.85 : 1**.** CAD was found in 20 males (83.33%) and 4 females (16.67%) out of 24 positive cases. So it can be concluded that incidence of CAD is more common in male sex which correlates with study done by **B. Adilakshmi et al**[146]and **RR Kasliwal et al.**[147]In study done by **RR Kasliwal**[147]**,** 88.4% were men and 11.6% were women.

RISK Factors
In our study, Hyperlipidemia was the most common overall and modifiable risk factor observed (70.83%) of the CTCA positive cases, followed by Hypertension (58.33%), Diabetes Mellitus (45.83%) and Smoking (37.5%).The findings correlate well with study done by **B. Adilakshmi et al**[146]and **RR Kasliwal et al**.[147]

In study done by **B. Adilakshmi et al**[146], Hyperlipidemia was found to be associated with 71% of cases of CAD and Diabetes Mellitus was present in 58% of the cases. In the study done by **RR Kasliwal et al**[147], 47.5% of all the patients were diabetics. History of smoking was present in 39.6% patients.

Positive family history was observed in 50% of the CAD cases in our study which correlated well with the findings in study done by **RR Kasliwal et al**[147], which found that more than half of the patients (54.5%) had at least one family member having CAD (irrespective of the age of onset).

None of the studied subjects in our study were underweight. 42% of the subjects belonged to the normal BMI category (18.5 to 22.9 Kg/m^2). 26% subjects belonged to the overweight category , 80.77% of them being males. The Obese I category (25-29.9 Kg/m^2) comprised of 29% subjects. Out of these 79.3% were males. Only 3% of total subjects belonged to Obese II category (>30 Kg/m^2).

DOMINANCE

In our study, majority of the patients had right coronary artery dominance (78%). The left coronary artery dominance was 18 % and co-dominance was seen 4 % of the patients.

The percentage of right dominance (78%) was comparatively less than the findings of **James *et al***(90%)[149], **Goldberg *et al*** (83.6%)[150] and **Knappen M *et al*** (81.2%)[151]but it corroborated with the study of **Bezbaruah NK**(76%)[152] and **Suman Inkhiya *et al*** (76.67%)[153].The percentage of the left dominance in our study was 18% was close to the observation of **Suman Inkhiya *et al***(13.33%) [153]and **Schelesinger**(18%). [154]

CORONARY CALCIUM SCORE

Coronary calcium score for each patient were calculated and graded according to scoring guidelines given by **Agatston**[78] .In our study Coronary calcium score Zero prevalence was 74 %. 26 subjects (26%) showed the presence of coronary calcium. Among the positive Calcium score subjects , Mild disease was most common with 10 patients (38.46%).Moderate coronary calcium score was found in 7 subjects (26.92%). Severe coronary calcium score was present in 4 of the subjects (15.38%)

None of the subjects in age group 20-29 yrs showed presence of coronary calcium.

Maximum number of subjects showing coronary calcium was in the age group 50-59 yrs (38.46%). The highest Coronary calcium score in studied subjects was 585 and the patient belonged to the age group 70-80yrs.

Age groups 60-69 yrs and 70-80 yrs showed 4 (15.38%) and 3 (11.54%) positive calcium score patients respectively. All the cases were in the Moderate and Severe calcium score category.

Coronary calcium score showed an increasing trend with age as 39% of subjects in age group 50-59 yrs showed coronary calcium, whereas 60% in age group 70-80 yrs showed positive calcium Score. Also, the higher age groups 60-69yrs and 70-80 years showed moderate and severe calcium scores and no mild or minimal calcium scores. Whereas in the age groups 30-39yrs and 40-49 yrs, none of the subjects had moderate or severe disease. In age group 50-59 years, Calcium score was more evenly distributed in the respective categories with Mild disease being the most common. Hence it also points out to that calcium amount was more as age progressed. This corroborates well with the studies done by **Schmermund et al** [97] **, Hoff J.A et al**[155],**McClealland R.L et al**[156]and **Alexandre C. Pereira et al.**[157]

21 out of 26 (80.77%) Calcium score positive patients were males. 10 out of 11 subjects(90.9%) in the Moderate and Severe calcium score category were males. This correlated with study done by **McClealland R.L et al**[156]and **Alexandre C. Pereira et al**[157],who in their study, concluded that men had greater calcium levels than women.

9.52% of subjects in the normal BMI (18.5 - 22.9 Kg/m^2) category showed coronary calcium deposits. In the overweight category (BMI 23.0-24.9 Kg/m2), 19.23 % of the subjects showed presence of coronary calcium. None of the subjects having BMI less than 25 were in the severe calcium score category.

In the Obese I category (25-29.9 Kg/m2), 55.17% had coronary calcium deposits. There was an increase in the coronary calcium content with increasing BMI.

10.34% of subjects in this BMI category showed Severe Coronary Calcium score.In the Obese II Category (>30 Kg/m2), 1 of the 3 (33.33%) subjects showed presence of coronary calcium deposits. It belonged to the Severe Calcium score category.Hence , all the Severe calcium score patients belonged to the Obese category. None of the Normal BMI and Overweight BMI patients showed >400 calcium score. It correlates with the study done by **Sabour S et al**[158], who found that obesity was associated with an increased risk for coronary artery calcification as compared to normal individuals.**Ki-Bum Won et al**[159] , in their study concluded that obesity was independently associated with increased risks of CACS >100.

Among the individual coronary arteries, calcium was found most frequently in the left anterior descending artery (76.92%), followed by the right coronary artery (53.85%) and left circumflex artery(50%) segments. This correlates well with study done by **Schmermund A *et al***[120], in which calcium was consistently found most frequently in the proximal left anterior descending coronary artery, followed by the proximal left circumflex and right coronary artery segments.[120]

CORONARY CT ANGIOGRAPHY

The percentage of CTCA positive cases in our study was 24%, whereas significant lesions (>50% stenosis) was found in 15% of total subjects (n=100). In a study by **Gupta et al**[3] in 2016, the prevalence of coronary artery disease in Indians was 9%-10% in urban and 4%-6% in rural populations. A higher CAD rate in our study is explained by the higher 'a priori' likelihood of CAD in our population, which is characterized by inclusion of only clinically suspected patients.

However the findings in our study correlate well with the study done by **Kavitha M. Chinnaiyan et al**[143], in which 50% stenosis was seen in 18.7% of the patients on CCTA.

Maximum number of subjects showing coronary plaque was in the age group 50-59 yrs (29.17%). The highest CADRADS grading was CADRADS 4 in this age group. Age groups 60-69 and 70-79 showed 4 (16.67 %) and 3 (12.50 %) CTCA positive patients respectively. Among the CTCA positive subjects (n=24), CADRADS 3 was most common with 8 patients (33.33%), followed by CADRADS 4 (29.17%) and CADRADS 2 (25%).None of the cases showed 100% luminal occlusion (CADRADS 5).

15 out of total 24 (62.5%) CTCA positive patients showed significantly occluded coronaries (>50% stenosis). Among these cases 10 (66.67%) were in the age group >50years and 5 cases (33.33%) belonged to the age group <50years. This finding corroborates well with the study done by **Zhong-Hua Sun et al**[160] who concluded that abnormal rates of coronary CT angiography increased significantly with increasing age .

90.48 % of the subjects with normal BMI had no evidence of any stenotic plaque on CTCA. Among the overweight category subjects (23.0 - 24.9 Kg/m2), 7.7% of the subjects showed significant disease. In the Obese I & II category (>25 Kg/m2), 12 out of the total 16 subjects (75%) had significant luminal occlusion.

Among the individual Coronary arteries, the Left Anterior Descending artery was the most commonly involved branch with LAD Proximal segment involved in 70.83 % of the positive cases. This was followed by the Proximal segment of Left Circumflex branch was involved in 54.17% of the positive cases and by Proximal segment of Right coronary artery (50%).Left Main Coronary artery was involved in 16% of the positive cases. The findings correlated well with the study done by **Gamal Eldine et al**[161] , in which the most commonly affected vessel was the Left Anterior Descending artery [40%] .

In our study, Triple vessel disease (3 vessels) was found in 41.67% of the cases. Among these cases, 9 out of total 10 (90%) triple vessel disease cases had atleast one significant (>50% occlusion) lesion. This was followed by Single vessel disease seen in 37.5% of the cases.2 vessel disease was found in 20.83% of the cases. Out of total CTCA positive cases (n=24), 15 cases (62.5%) had atleast one significant (>50% occlusion) lesion.

STRESS TREADMILL TEST

Out of the total 24 positive cases diagnosed by CTCA, 66.67% of the cases were positive on Treadmill Test whereas, 8.33% showed negative results. 25% of the CTCA positive cases were inconclusive on TMT.

Among the CTCA negative cases, 78.94 % of the negative cases were also negative on Treadmill Test whereas, 14.47 % were overestimated as positive result.6.59% of the CTCA negative cases were inconclusive on TMT.

From the above data keeping CTCA diagnosis as the final diagnosis, the sensitivity and specificity of TMT was concluded to be 66.67 % and 78.95 %. It was 76 % accurate as compared to CTCA. The Positive predictive value was 50 % whereas the negative predictive value was 88.24% (p-value 0.00003)

The findings correlated well with the studies done by **Amir Ali Rahsepar et al**[162] who concluded that without imaging, the sensitivity of an exercise treadmill test for detecting CAD is only modest, i.e. approximately 70%, while specificity is good (75–80%). In another study by **Maffei E et al**[163], it was found that the sensitivity of Stress ECG was 47%, specificity 53%, positive predictive value (PPV) 51% and negative predictive value (NPV) 49% who correlated well with our findings.

SUMMARY AND CONCLUSION

The present study was undertaken to determine the role of Coronary CT Angiography in patients with suspected coronary artery disease. There were 100 suspected cases of Coronary Artery Disease evaluated by Non Contrast Calcium scoring followed by CTCA.

Out of hundred patients, 24 were having Coronary artery disease while 76 subjects were free of disease. Most common modifiable risk factor was Hyperlipidemia followed by Diabetes Mellitus. Positive family history was present in half of the positive cases.

Coronary calcium score showed an increasing trend with age and males had greater calcium levels than females. There was also an increased risk of coronary calcium with increasing BMI.

Among CTCA positive subjects (24), 83.33% were males, suggesting male preponderance of the disease. Most common artery involved was Left Anterior Descending Artery. Majority of the patients had right coronary artery dominance (78%). Significant stenosis (>50%) was present in 15% of the subjects.

As compared to CTCA, Stress TMT revealed limited accuracy. It showed a sensitivity of 67%, specificity of 79% and accuracy of 76%. CTCA was also of great value in patients with inconclusive TMT results. It accurately demonstrated the extent, distribution and severity of coronary artery disease in patients presenting with symptoms suggestive of CAD. CTCA was able to differentiate between calcified, soft and mixed plaque. CTCA is a simple, convenient, non-invasive, time efficient tool for evaluation of coronary artery luminal status as well as anomalies. Further, it gives us a three dimensional evaluation of the coronary vessel architecture. By effectively ruling out CAD it acts as an effective gatekeeper for further invasive testing using CA.