Role of computed tomography coronary angiography in evaluation of coronary artery disease

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Purpose

To discuss and evaluate application of computed tomography coronary angiography (CTCA) in coronary artery diseases (CAD) in low and intermediate risk population, post Coronary Artery Bypass Grafting (CABG) and post Per-cutaneous Trans-luminal Coronary Angioplasty (PTCA) to evaluated their follow-up in a non-invasive manner.

In this poster, we will review the role of Multidetector CTCA with a special attention in scanning and reformat protocols for proper evaluation of coronary arteries and their diseases.

CTCA permits non-invasive evaluation of both the coronary lumen and the vessel wall. Coronary plaque can be detected and classified into calcified, non-calcified and mixed plaques and their impact on coronary lumen can be evaluated. Moreover, CTCA permits evaluation of the extents (e.g. - number of diseased coronary segment), size and anatomical distribution of coronary plaques. Recent literature indicates that such comprehensive assessment may have prognostic value and may aid in the risk stratification of patient suspected of CAD.

Methods and Materials

Our Population:

From the database of CTCA of our institute (November 07-September 09), we enrolled 136 patients with suspected CAD to evaluate coronary arteries and CS, highest number of cases in the age range of 51 - 60 yrs. There was varied clinical presentation, most of the patient presented with atypical chest pain and underwent contrast enhanced CTCA in a 40 slice CT scanner.

The report of CTCA was used to evaluate diagnostic accuracy using the threshold for significant stenosis at > 50%. The study also included 5 cases of post CABG and 5 of post PTCA for evaluation of grafted and stented vessels. Another 5 cases were also evaluated as a part of their per-operative cardiac check-up for some elective surgery. For CTCA, the targeted heart rate was 70 beats per minutes, for which ß-blocker was given if required, atleast 3 hrs. fasting was necessary.
Calcium Scoring (CS) was performed in all those cases except in post CABG and post PTCA patients. The presence of calcium was determined by using Agatston method on page for MDCT with a 130 HU threshold. The coronary arteries were assessed for stenosis in the optimal ECG phase, each vessels was classified as significantly stenosed (> 50%) or not significantly stenosed.

**MDCTA scanning protocol:**

40 Slice MDCT Scanner.
18G IV cannula in an ante-cubital vein.
Scanogram: Lung Apex to Diaphragm.

Scan volume:Aortic arch to the diaphragmatic surface of heart in cranio-caudal direction.

Collimation: 40X0.6 mm with Z axis flying focal spot.

Tube voltage: 120 kV

Current: 765 mAS
100 ml @ 4.5 ml/s iodinated ,non-ionic monomar contrast medium (370 mgI/mL) + 50 ml @ 4.5 ml/s saline chase (use of a dual-barrel high-power injector on page mandatory).[3]

Retrospective ECG Gating - MDCT acquisition model.

Patient breath-hold about 15-18 sec.

Bolus timing technique: Real Time Bolus tracking, start delay defined by circular region of interest positioned at ascending aorta & data acquisition automatically 5 sec after reaching triggering threshold (140 HU).

Post CABG: mammary graft origin to be included and studies (Fig.1).

Total patient room time approx. 15 min.
Fig.: Cardiac CT Preparation: Patient counseling for proper breath hold, ECG monitoring, preparation for contrast administration etc.

References: R. Saikia; Radio-diagnosis, Primus, G S road, Assam, India, Guwahati, INDIA

Post processing reconstruction of source images, formatting & interpretation:

Cross sectional images from aortic arch to cardiac apex, slice thickness of 0.75mm in an increment of 0.5mm, a small field of view, soft reconstruction kernel (B 30f) to generate curved MPRs and MIP images of coronary arteries.

Images were reconstructed in the diastolic phase of cardiac cycle to reduce cardiac motion artifact.

Image interpretation requires 3D workstation.

For detailed coronary evaluation, we employed:

- MIP (maximum intensity projection)(Fig.2).
Coronary Calcium Scoring:

Coronary calcium is a surrogate marker of coronary atherosclerosis and gives an idea about the risk of plaque burden and helps to evaluated risk of CAD, though zero calcium score does not exclude always CAD.

<table>
<thead>
<tr>
<th>CS(Agartston)</th>
<th>Plaque Burden</th>
<th>Probability of significant CAD</th>
<th>Implications for cardiovascular risk</th>
<th>Recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No identifiable plaques</td>
<td>Very low</td>
<td>Very low</td>
<td>Reassure patient</td>
</tr>
<tr>
<td>1-10</td>
<td>Minimal identifiable plaque burden</td>
<td>Very unlikely</td>
<td>Low</td>
<td>Discuss guideline for primary prevention of CAD</td>
</tr>
<tr>
<td>11-100</td>
<td>Mild atherosclerotic plaque</td>
<td>Mild or minimal stenosis likely</td>
<td>Moderate</td>
<td>Counsel risk-factor modification, daily Acetyl salicylic acid</td>
</tr>
<tr>
<td>101-400</td>
<td>Moderate atherosclerotic plaque</td>
<td>CAD highly likely,</td>
<td>Moderately high</td>
<td>Institute risk-factor modifications, exercise testing</td>
</tr>
<tr>
<td>More than 400</td>
<td>Extensive atherosclerotic plaque burden</td>
<td>High likelihood of significant coronary stenosis.</td>
<td>High</td>
<td>Aggressive risk-factor modification, exercise or pharmacological stress test</td>
</tr>
</tbody>
</table>
Characterization of Plaque:

- CT attenuation can reliably differentiate b/w lipid laden plaque and fibrous plaque and initiate early therapy.
- The various studies done to compare plaque detection and composition by MDCT and intra coronary ultrasound (gold standard) have shown identical results.
- MDCTA allows for the detection of early changes even before the narrowing of lumen is evident (Fig.5).
- Vulnerable plaque prone to rupture with subsequent thrombus formation causing MI is easily detected by MDCT (Fig.6).

MDCTA Plaque Features:

<table>
<thead>
<tr>
<th>MSCT features</th>
<th>Density (HU)</th>
<th>Advanced plaques (AHA)</th>
<th>Progressive atherosclerotic lesion (modified AHA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-density</td>
<td>&gt;150</td>
<td>............</td>
<td>Calcific nodule</td>
</tr>
<tr>
<td>High-density</td>
<td>&gt;150</td>
<td>calcified plaque</td>
<td>............</td>
</tr>
<tr>
<td>High-density</td>
<td>............</td>
<td></td>
<td>Fibrocalcific plaque</td>
</tr>
<tr>
<td>Intermediate</td>
<td>50-100</td>
<td>fibrous plaque</td>
<td>fibrous cap atheroma</td>
</tr>
<tr>
<td>Low density</td>
<td>20-50</td>
<td>(fibro) atheroma</td>
<td>thin fibrous cap atheroma</td>
</tr>
<tr>
<td>Very low density</td>
<td>&lt;20</td>
<td>complicated plaque</td>
<td>thrombous</td>
</tr>
</tbody>
</table>

Source: The Radiograph, Jan.2008

Comparison between MDCTA and cardiac catheterization for detection of significant coronary artery stenosis:[3]

<table>
<thead>
<tr>
<th>Author</th>
<th>Patients (n)</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Positive predictive Value</th>
<th>Negative predictive Value</th>
</tr>
</thead>
</table>

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<table>
<thead>
<tr>
<th>Study</th>
<th>Cases</th>
<th>Sensitivity</th>
<th>Specificity</th>
<th>Accuracy</th>
<th>Positive Predictive Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nieman (2001)</td>
<td>35</td>
<td>83%</td>
<td>90%</td>
<td>81%</td>
<td>97%</td>
</tr>
<tr>
<td>Achenbach (2001)</td>
<td>64</td>
<td>85%</td>
<td>76%</td>
<td>59%</td>
<td>98%</td>
</tr>
<tr>
<td>Knez (2001)</td>
<td>44</td>
<td>78%</td>
<td>98%</td>
<td>85%</td>
<td>96%</td>
</tr>
<tr>
<td>Nieman (2002)</td>
<td>58</td>
<td>95%</td>
<td>86%</td>
<td>80%</td>
<td>97%</td>
</tr>
<tr>
<td>Ropers (2003)</td>
<td>77</td>
<td>92%</td>
<td>93%</td>
<td>79%</td>
<td>97%</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>87%</td>
<td>89%</td>
<td>77%</td>
<td>97%</td>
</tr>
</tbody>
</table>

Artifacts in CTCA Data Processing:

- Blurring- due to calcification, Stents, Obesity etc.
- Streak - Due to high contrast difference.
- Stab - Improper use of contrast giving bands of different intensities.
- Step - Caused by movement either of heart or the patient.
Fig.: Some of Artifacts During CTCA

References: R. Saikia; Radio-diagnosis, Primus, G S road, Assam, India, Guwahati, INDIA

Images for this section:
**Fig. 1:** IHD, Post CABG- C/O chest discomfort. Clinical diagnosis - Critical IHD. Graftings performed during CABG: LIMA-LAD, SVG-OM2, SVG-D1 & SVG-RCA
Fig. 2: 60yr/M, Smoker, HT, Dyslipidemia, Presenting with one episode of chest pain, CS - Nil, MDCTA - Soft plaque in LAD & Cx, 85-90% narrowing.

Fig. 3: MPR Images of Normal Coronaries
**Fig. 4:** Circulation & VRT Images: Anatomical variant, SA nodal branch from CX

**Fig. 5:** Patient with Acute Coronary Syndrome, MDCTA - LAD extensive soft plaque. Cath. Angio at that time-only mild changes. Patient presented with STEMI after 3 weeks, Cath. Angio then demonstrated obvious subtotal occlusion.
Fig. 6: Visualization of "vulnerable plaque", CTCA & Conventional Angiography.
Results

The prevalence of disease demonstrated at CTCA was 71% (97/136), 28 cases were normal CTCA and 5 cases only calcium with no significant stenoses (Fig.1). Three cases were excluded from the analysis due to non-diagnostic quality of CTCA.

References: R. Saikia; Radio-diagnosis, Primus, G S road, Assam, India, Guwahati, INDIA
Risk factor profile was also evaluated showing underlying hypertension in 35% of cases to be the top of the list (48/136) followed by diabetes mellitus (21/136) and dyslipidemia (19/136).
Sixteen cases of strongly positive treadmill test (TMT) were showing negative CTCA findings (Fig.2).
The 5 cases each of post CABG & PTCA showed promising result in evaluation of recent disease status by assessing the treated & grafted vessels and so on (Fig.3, 4 & 5).
Fifty two cases had CS < 400, while 14 cases not having coronary calcium but positive findings in CTCA (Fig.6), 13 cases had CS > 400.
It was observed that the heart rate did showed significant influence on diagnostic accuracy, while the absence or the presence of low CS on page improves diagnostic quality (Fig.7).
It was also observed additionally that CTCA able to delineate anatomical variations and anomalies of coronary arteries apart from detecting obstructive CAD only (Fig. 8 & 9).
**Fig. 1:** 45yr/M, Strong Family H/O CAD, presenting with occasional chest discomfort. MDCTA - CS 162, No Significant narrowing.

**Fig. 2:** 50Yr/F, chest pain, TMT positive for exercise induced ischemia, deranged lipid profile. MDCTA : No significant stenosis or wall plaque.
Fig. 3: IHD, Post CABG- C/O Chest discomfort. Clinical diagnosis - Critical IHD. Graftings performed during CABG : LIMA-LAD,SVG-OM2,SVG-D1 & SVG-RCA
Fig. 4: 64yr/M, Status post CABG, Recent onset dyspnoea and chest discomfort. Preoperative angio-CAD with tight left main stenosis, good LV function. Graftings done: LIMA-LAD, SVG-OM, Radial-RCA.
Fig. 5: 52 yrs Male, Post PTCA, on follow up to know the status of stent
Fig. 6: Zero Calcium Score !! Lesion in Left Anterior Descending Artery

Fig. 7: 77 years Male, Dyslipidemia, ECG - Anterior lateral ischemia. Total Calcium score 2382.2
**Fig. 8:** Intra-myocardial Course of LAD: Mimics Stenosis in Conventional Angiography.

**Fig. 9:** 62 yrs, Male, old ASMI, MDCTA:MIP & VRT Images; Fusiform Dilatation of LAD.
Conclusion

The study suggests a learning curve of diagnostic accuracy of CTCA. The excellent negative predictive value and negative likelihood ratio makes CTCA a non-invasive gold standard for the exclusion of significant CAD.

The new generation MDCT allows good image quality in CTCA. MDCTA provides mural and luminal anatomy yielding diagnostic imaging for stenoses and detection of hard and soft plaques\(^3\).
Successful development of this technology with consistently high sensitivity and specificity for obstructive CAD would greatly reduced the cost and also the morbidity and mortality associated with conventional angiography.

This study suffers from some limitations. We evaluated quality of coronary artery images in CTCA, but could not compare with conventional coronary angiograms always. Hence it was not possible to determine accurately the degree of stenoses in all the time. Cases with acute angina and high probability of obstructive CAD still require immediate invasive angiograms with the option of treating potential stenoses, which makes it obvious that conventional angiogram cannot be replaced by CTCA\(^8\). Also, the systematic overestimation due to blooming in dense calcifications indicates that invasive angiography will remain necessary in many cases to clarify results of CTCA as because we were not following any clearcut demarcation of CS to consider contraindication for CTCA.

Still, CTCA will be very helpful to reliably exclude significant coronary artery disease, follow-up of post CABG and PTCA cases. Rapid growth in both knowledge and experience will lead to wider clinical use of this technique; a trend towards cardio-thoracic imaging is going to be reinforced with new generation scanners using dual tube.

References


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