

ADVANCES IN CARDIAC CT IMAGING IN CORONARY ARTERY DISEASE

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INTRODUCTION

Coronary Artery Disease (CAD) is a disease that causes reduced blood flow in one or more of the arteries that circle and supply the heart. CAD is usually a degenerative disease and common by the age of 60 years. One in four people will have a heart attack. The first recognized symptom may be death⁹. The highest death rates for heart and blood vessel diseases in South Africa are found in Indian people, followed by the colored people and the white and black people have the lower chances¹¹.

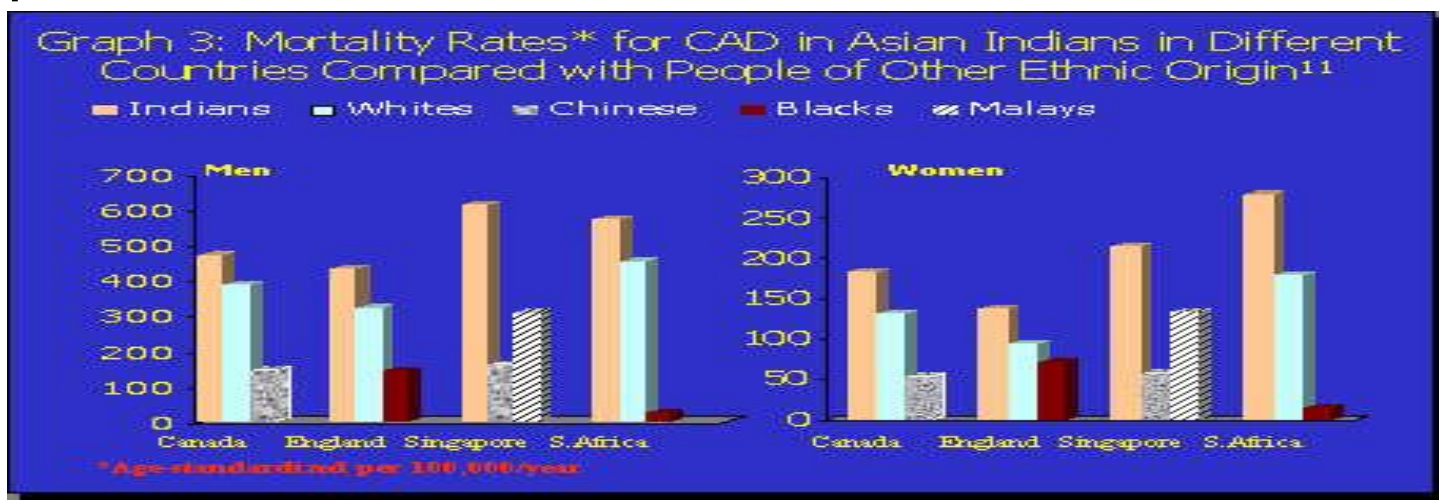


Figure 1: Bar graph illustrating mortality rates for CAD highest in Asian Indians in different countries⁶.

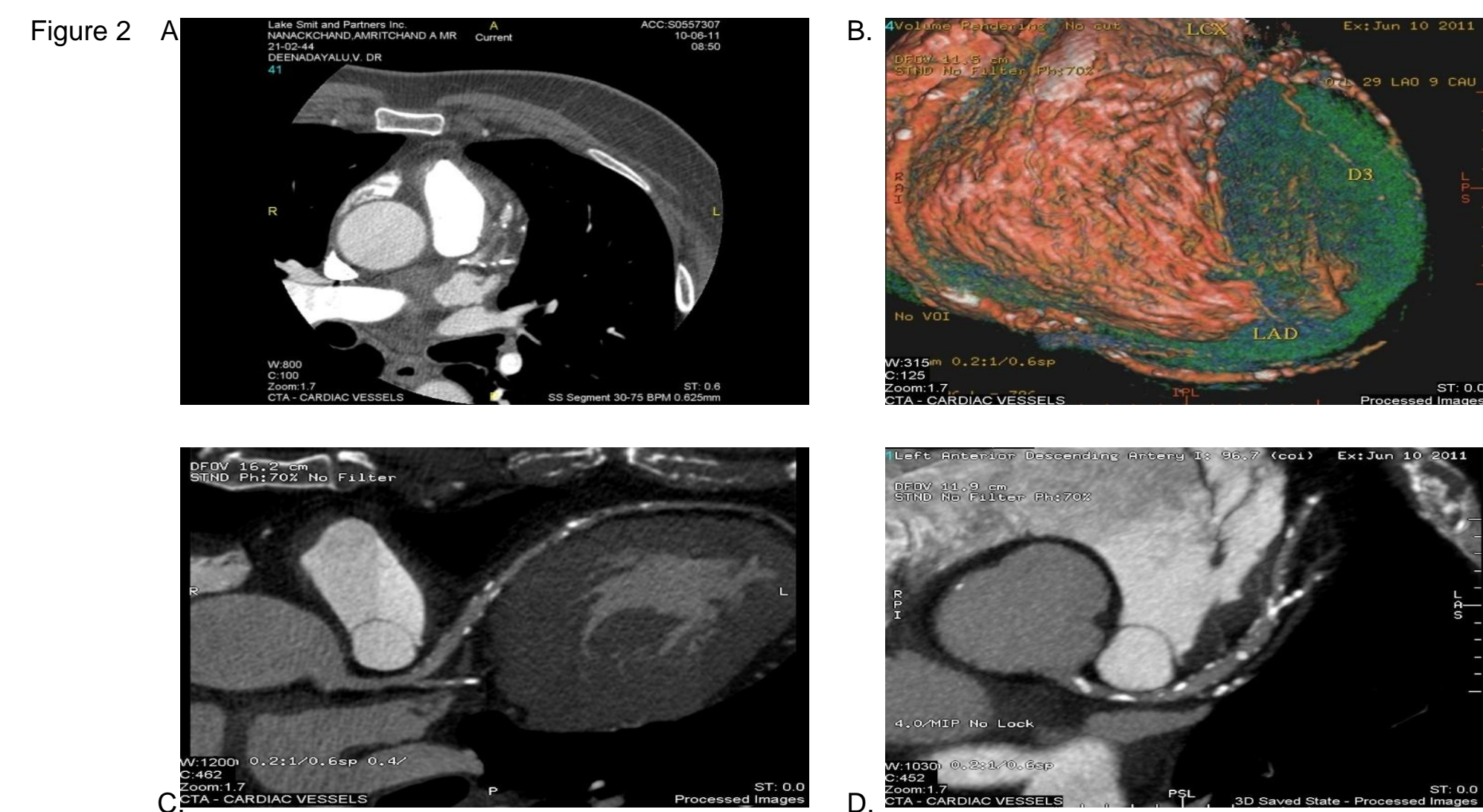
The current obesity epidemic is responsible for the increased numbers relating to coronary artery disease. Tests such as ECG, treadmill stress test, stress thallium, dobtamine stress echo and dobtamine stress MRI are done to rule out CAD¹⁴. However Computed Tomography (CT) imaging of the heart has moved into a new era with the introduction of Multislice CT (MSCT), the development of electrocardiography (ECG) synchronized scanning and reconstruction techniques¹⁰.

CASE REPORT

A 62 year old Indian male presented to the casualty department with chest pain, dyspnea and syncope. On physical examination a loud systolic murmur was heard. His vital signs were; BP =190/120 mm Hg and an irregular heart rate of 60 Beats per Minute. An ECG demonstrated sinus arrhythmia with PR intervals of 114 and a Peak T wave of V3-V5 which is suggestive of decreased cardiac function. The patient was referred to radiology for a CT Angiography of the coronary arteries. The scanning technique employed was:

Detector configuration 64 x 0,625mm at 40mm coverage per rotation.
Gantry speed: 0, 5 seconds.
Scan time: 11,8 seconds
Scan coverage: 236mm
Contrast 100cc and 50cc saline

The findings of the CT scan demonstrated extensive coronary artery calcification along with soft plaque, which is best seen in cardiac CT, resulting in advanced CAD. Conservative management of the patient was undertaken with beta blockers.

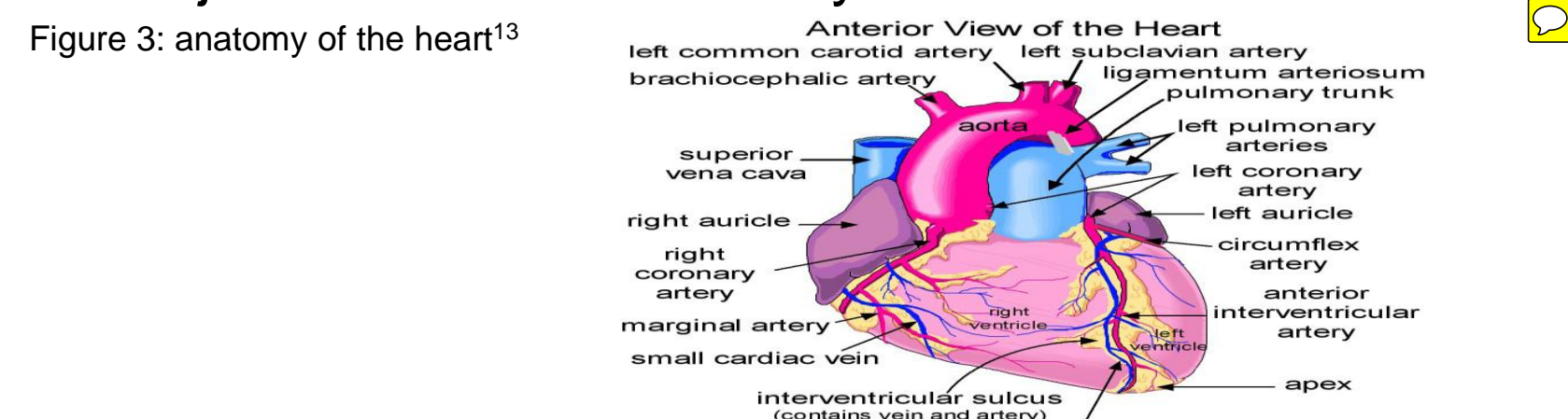


There is extensive antheromatous plaque formation along the entire course of the left anterior descending artery down to the apex of the heart. The left circumflex artery demonstrates dominant plaque and a degree of stenosis involving the mid portion of this artery.

A coronary CTA is considered less invasive than cardiac catheterization and takes considerably less time to perform. Cardiac CT is the only modality that directly allows one to accurately depict coronary artery anatomy and pathology and is superior to any direct method in confirming CAD¹⁴.

DISCUSSION

The heart muscle must have adequate blood supply to contract properly. The coronary arteries carry oxygen and blood to the myocardium. When a coronary artery is narrowed or blocked, the area of the heart muscle supplied by that artery becomes ischemic and injured and infarction may result¹⁵.



Multislice CT has evolved over the years, particularly with scanners having 64 or more detectors therefore making it the imaging modality of choice (figure 4). MRI is an optimal tool for measurements of cardiac function due to its high spatial resolution and tissue contrast. The development from a single slice to currently a 256 slice CT scanner has brought about a leap in technical innovation especially in detector design and technology².

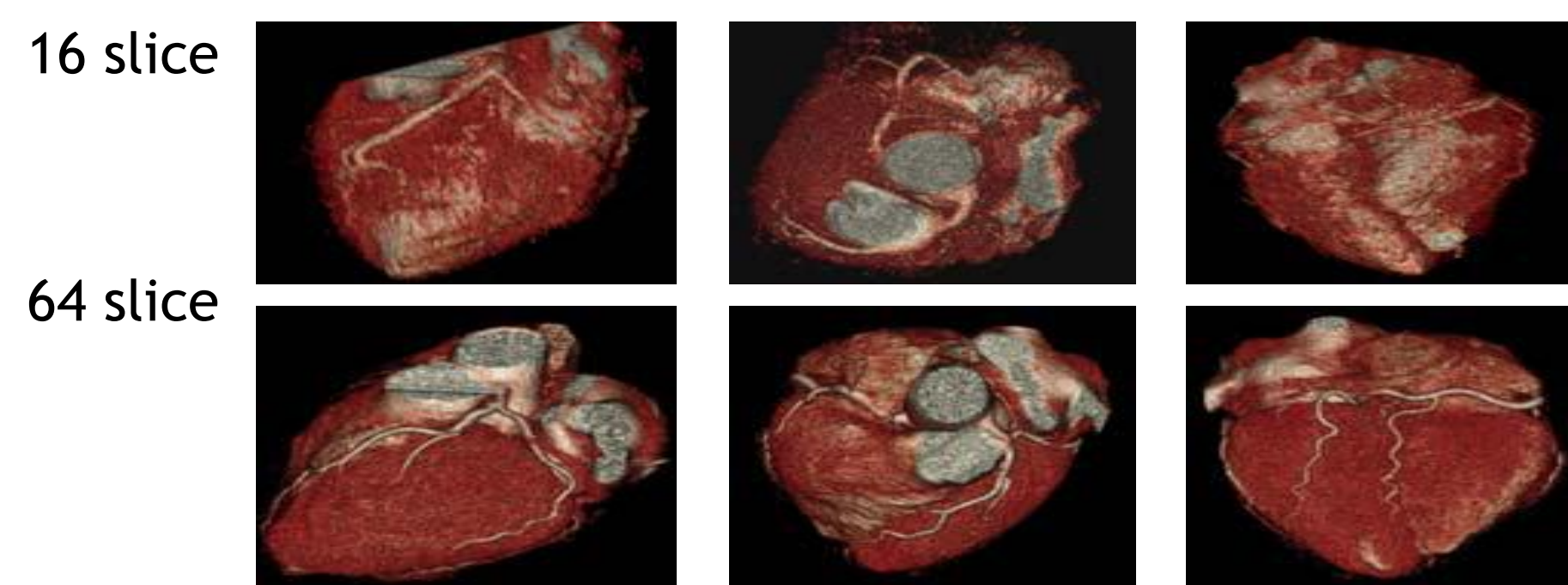


Figure 4: illustrates a comparison between the top row of VR images of coronaries performed on a 16 slice CT to the bottom row of images from a 64 slice scanner⁸.

CORONARY CTA

- The 256 slice scanner can successfully visualize the coronaries, myocardial contraction and myocardial enhancement during a single imaging exam².
- It is now possible to acquire images of the coronary arteries and maintain the radiation dose as little as 2mSv per second².
- A wide variety of post processing techniques are available with MSCT, including multiplanar reconstruction (MPR), maximum intensity projection (MIP) and volume rendering (VR) allow noninvasive assessment of every aspect of the cardiovascular system⁸.
- MPR are useful for evaluating the cardiac chambers and left ventricular function (LV)⁸.
- MIP is similar to traditional angiograms which display intraluminal opacity values. The only limitation is that they lack depth and spatial information to adjacent structures⁸.
- VR aids in surface evaluation of the heart and coronary arteries. It is most useful in evaluating complex anatomy, including coronary artery anomalies, bypass grafts and fistulas⁸.

The aim of cardiac CT for calcium scoring is to identify CAD at an early stage when there are no symptoms and to establish its severity⁴.

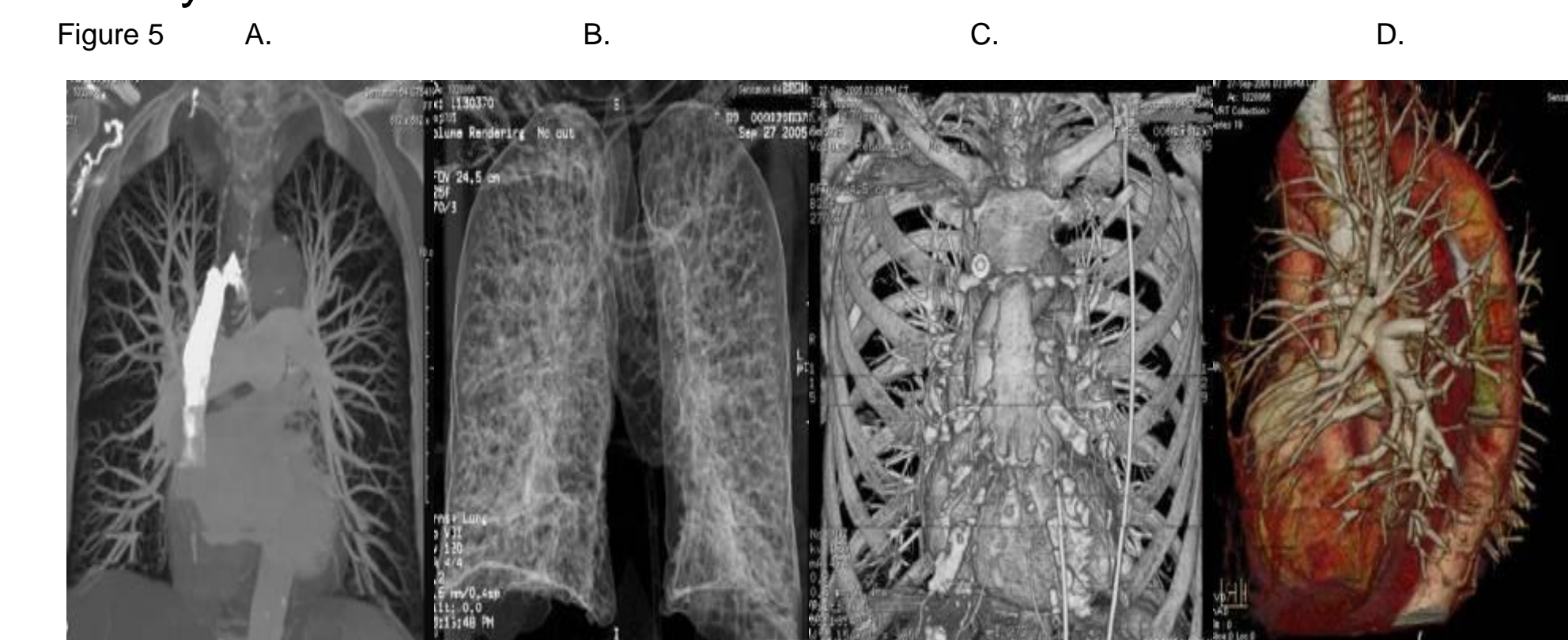


Figure 5 A demonstrates- MIP of pulmonary vessels; figure 4 B. VR of the lungs; figure 4 C –VR of the bony structures of the chest and figure 4 D- VR of the heart and major blood vessels

WHAT IS CORONARY ARTERY CALCIUM SCORING?

The presence of any calcium in the coronary tree is diagnostic of coronary atherosclerosis. Atherosclerosis is a process that results in deposition of calcium within the wall of an artery¹. Electron beam CT (EBCT) has been able to calculate the amount of calcium in the coronary arteries, and is used as a tool to predict the risk of CAD. However calcium scoring is valuable when performed with Multislice Cardiac CT Angiography to assess the calcium load of the coronary arteries³.



Figure 6: An unenhanced gated study of the heart was performed to assess for coronary artery calcification and demonstrates calcification along the entire coronary artery tree. It gives a calcium score of greater than 2400 and places the patient in the 90th percentile for age.

ECG GATING

The radiation dose associated with retrospective ECG gating is gradually increased with the increased number of detector rows. Doses from 64-slice scanners will be lower than those acquired with 256 and 320 slice scanners. It is important to reduce the radiation dose while using MSCT angiography in cardiac imaging. Therefore prospective ECG-gating is the most effective and significant technique to reduce radiation dose¹².

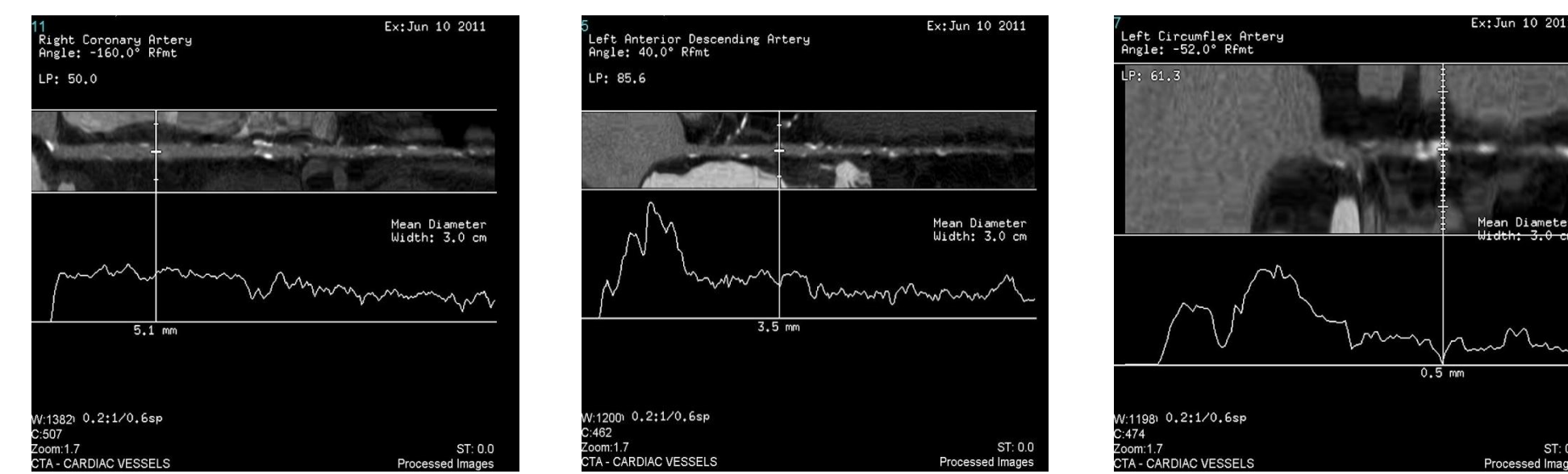


Figure 7 The patients resting heart rate prior to the study was approximately 60 BPM as the heart rate had already been reduced with the patient's own personal beta blockers.

BENEFITS VS RISKS

BENEFITS

- Coronary CTA and calcium scoring is a simple and non invasive way of evaluating the coronary arteries⁴.
- CT has an advantage over other imaging modalities in that it is able to view bone, soft tissue and blood vessels all at the same time⁴.
- CT examinations are fast and cost effective⁵.
- CT can be performed regardless of implanted medical devices, unlike MRI⁵.
- Angiography eliminates the need for surgery. If surgery is a necessity, it provides accuracy⁵.
- Cardiac CT for calcium scoring can identify CAD, even when the coronary arteries are less than half narrowed. Other cardiac tests will not reliably demonstrate the level of blockage, therefore more than half of all heart attacks occur with less than 50% narrowing⁴.

RISKS

- There is possibility of cancer from the radiation. However the benefit of an accurate diagnosis outweighs the risks⁴.
- The results of cardiac CT are sometimes seen positive although there is no major blockage of the coronary arteries. This may lead to the patient undergoing further tests which are not necessary and these may have side effects⁴.

CORONARY CT VS CARDIAC MRI

- CT has higher spatial resolution than MRI¹⁰.
- MRI does not require contrast agents whereas CT does⁴.
- CT has temporal resolution of 0, 33 - 0, 5 msec, whereas cardiac MRI has a temporal resolution of 20- 50 msec that can be achieved⁴.
- Valve motion and function can be assessed semi quantitatively with both CT and MRI¹⁰.
- CT makes use of ionizing radiation whereas there is no radiation involved in MRI¹⁰.

ADVANCES

Cardiac CT continues to grow, due to the development of the 128, 256 and 320 slice scanners. The 320 slice scanner can image the heart in a single heart beat, and delivers superior temporal resolution. However the major concern is radiation dose relating to cardiac CT. PET/CT is a non invasive procedure that helps identify areas of abnormal myocardial perfusion. It can also determine the functionally capacity of the heart muscle, separate viable from non viable tissue and accurately locate a defect. PET/CT imaging has higher sensitivity and specificity for diagnosing CAD⁷.

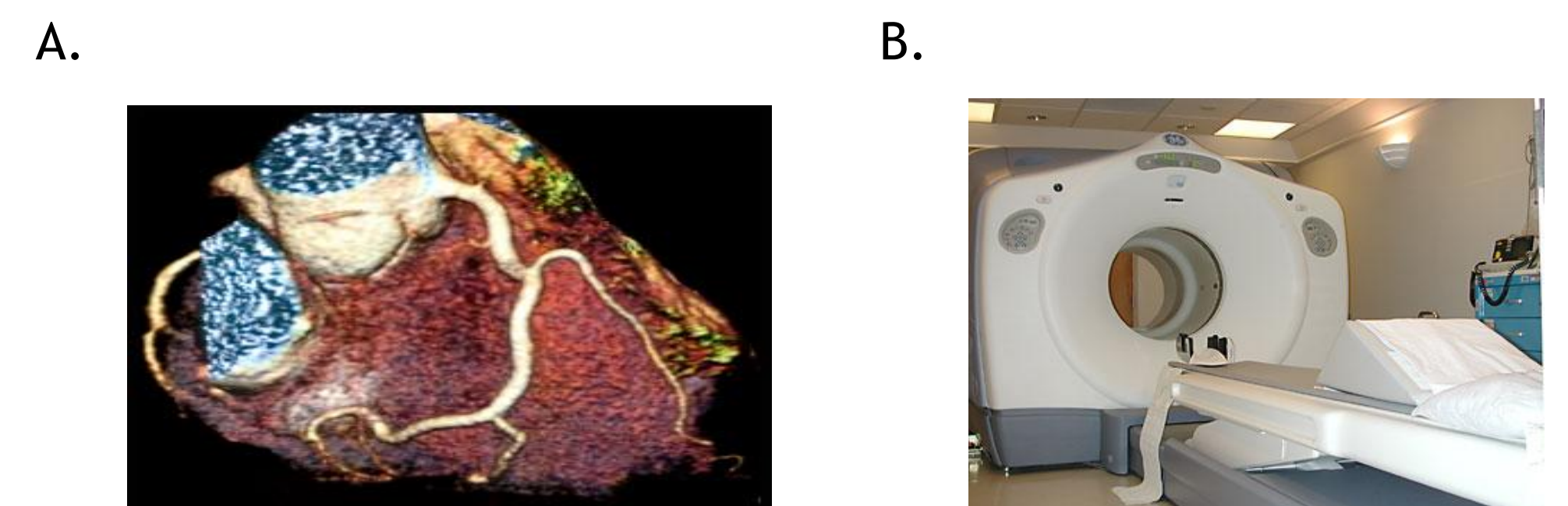


Figure 8 A. PET/CT image of the heart demonstrating viable and non-viable tissue. Figure 8 B - PET/CT scanner⁷.

CONCLUSION

The social economic importance of heart disease has provided motivation for the development of a radiological tool for noninvasive imaging of the heart. CT has been embraced as the leading modality for cardiovascular imaging. Imaging of the heart however has always been technically challenging because of the continuous motion the heart displays. However Cardiac CTA is revolutionizing cardiac imaging thus allowing evaluation of the heart and coronary arteries. Calcium scoring in conjunction with cardiac CT is a breakthrough that allows clinicians to determine precisely and noninvasively whether or not CAD is present in asymptomatic individuals. This therefore plays a pivotal role in the evaluation and follow up care for all CAD patients¹.

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