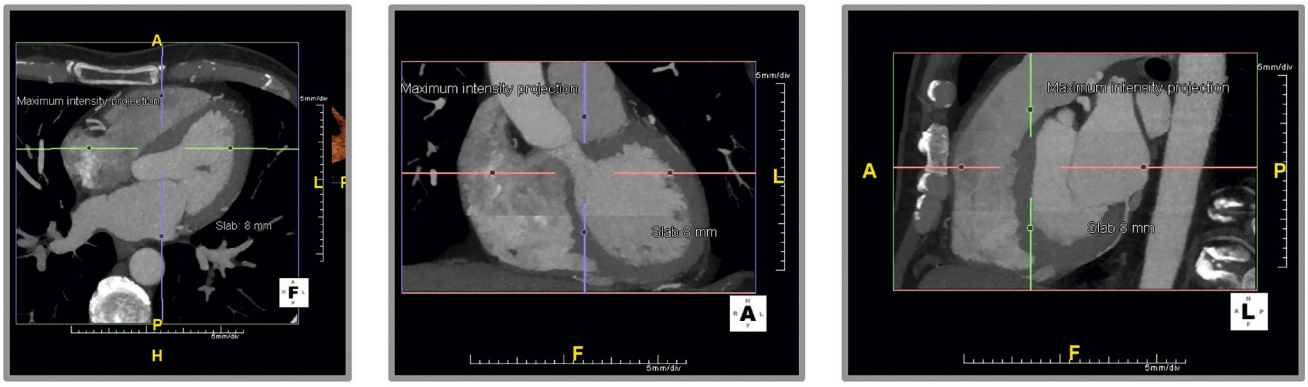
Cardiac CT
Chapter 3

CT IMAGING OF THE HEART AND CORONARY CIRCULATION

Ronak Rajani

CT imaging of the heart and coronary circulation

USING MULTIPLANAR IMAGING ON CARDIAC CT



Multiplanar imaging refers to the display of CT datasets in three different planes.

Axial

Axial–transverse images which represent slices of the body.

Coronal

Coronal—images are taken perpendicular to the sagittal plane,
which separate the front from the back (this is also known as the frontal view).

Sagittal

Sagittal—images are taken perpendicular to the axial plane and separate
the left and right sides (this is also known as the lateral view).

A maximal intensity projection is where the voxels, with the highest attenuation values on every view throughout the volume, are projected onto the 2D image. The Maximal intensity projection (MIP) slice thickness (also known as slab thickness) can be changed to be wider. Although this reduces image noise, the spatial resolution is decreased.

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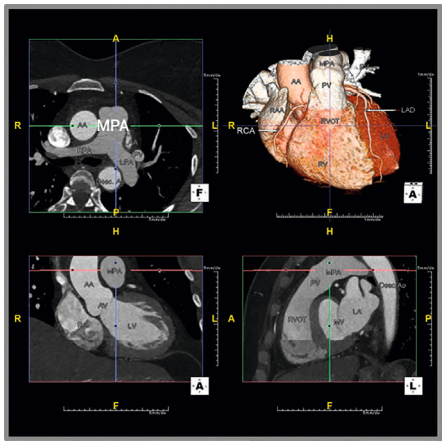
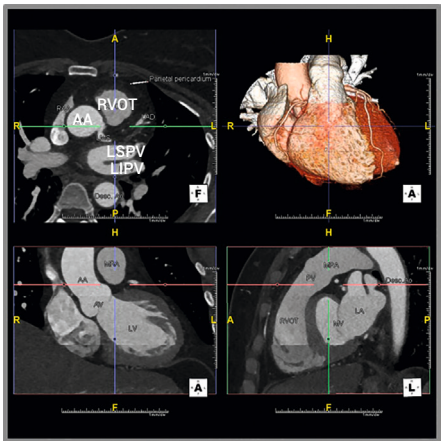
THE NORMAL HEART STRUCTURES ON A CT SCAN

In the following images we display the various cardiac structures of the heart that can be seen at different levels in the chest.

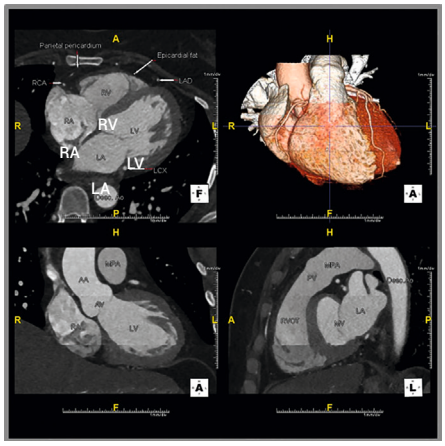
Level of MPA



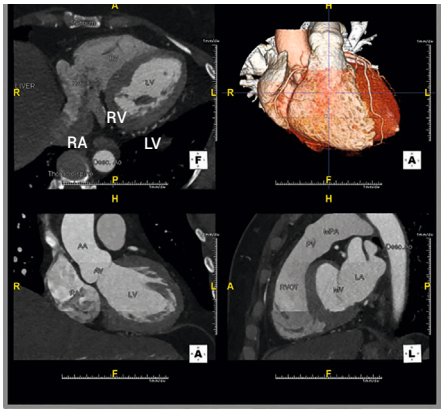
Aortic root



Four chambers



Inferior–coronary sinus level



Ao—aorta
AV—aortic valve
Desc. Ao—descending aorta
LA—left atrium
LAA—left atrial appendage
LAD—left anterior descending artery
LCX—left circumflex artery
LIPV—left inferior pulmonary vein
LSPV—left superior pulmonary vein

LV—left ventricle
LVOT—left ventricular outflow tract
MPA—main pulmonary artery
MV—mitral valve
RA—right atrium
RCA—right coronary artery
RV—right ventricle
RVOT—right ventricular outflow tract

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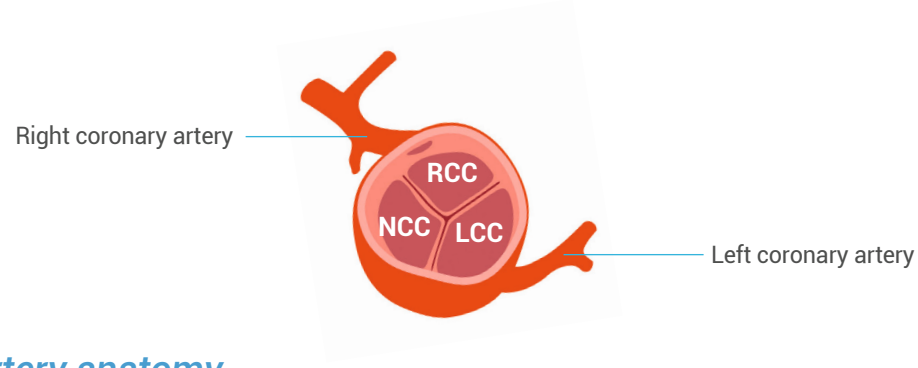
RECOGNIZING THE CORONARY ORIGINS ON CT

Coronary origins

The right coronary artery arises from the right coronary cusp (RCC), and the left coronary artery from the left coronary cusp (LCC).

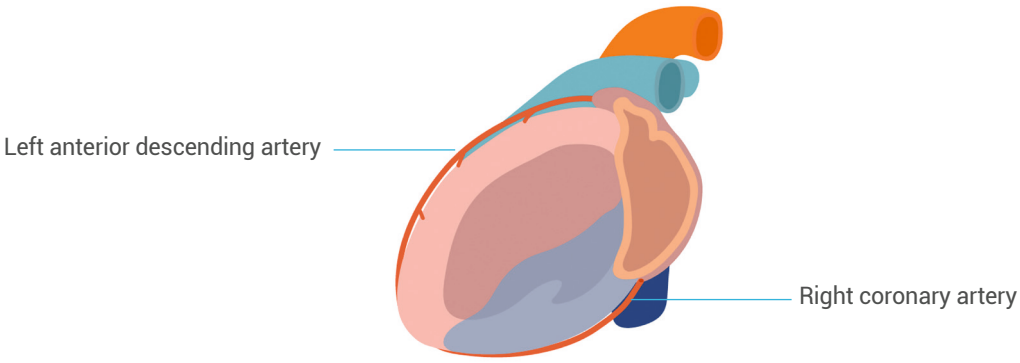


Left coronary artery anatomy

The left coronary artery usually splits into the left anterior descending and left circumflex arteries (bifurcation anatomy).

Coronary dominance

This refers to whether the right coronary artery supplies the posterior descending artery of the left ventricle (right-sided coronary dominance), or if the left circumflex artery does (left-sided coronary dominance).



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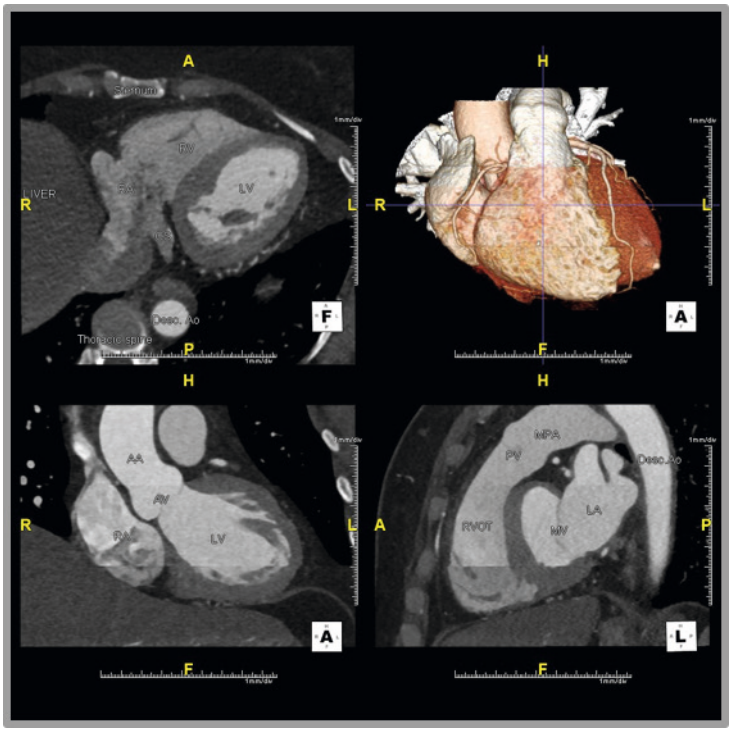
CORONARY ARTERY IDENTIFICATION

This volume-rendered (VR) image shows the coronary arteries on a 3D image. The left coronary artery (LCA) arises from the left coronary cusp (LCC), before separating into the left anterior descending (LAD) and left circumflex artery (LCX) in bifurcation anatomy, and a ramus branch with trifurcation anatomy. The LAD follows the anterior interventricular groove (running anteriorly) and the LCX follows the left-sided atrioventricular groove (wrapping posteriorly). The right coronary artery (RCA) arises from the right coronary cusp (RCC), passing anteriorly in the chest and along the right-sided atrioventricular groove.



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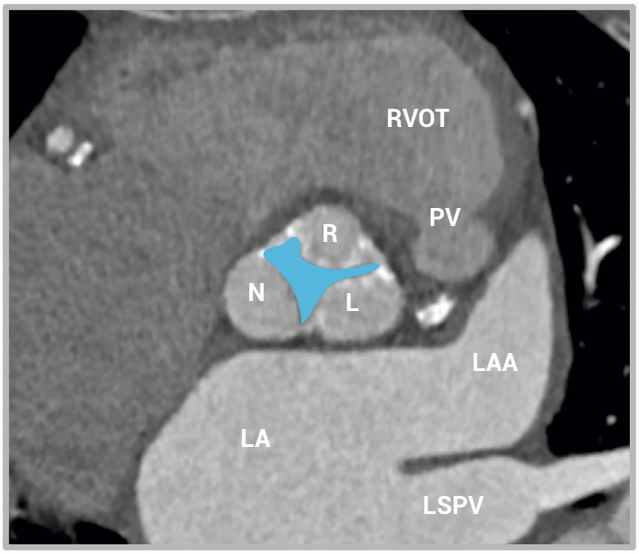
EVALUATING THE AORTIC VALVE

The aortic valve is normally tricuspid, meaning that it has three valve leaflets. These are labelled by their relationship with the coronary arteries; the left coronary cusp (LCC), the right coronary cusp (RCC), and the non-coronary cusp (NCC). To identify which cusp is which remember that the RCC is the most anterior of the cusps and the NCC is the one that lies adjacent to the interatrial septum. The LCC is the cusp from which the left coronary artery arises, in patients with normal coronary anatomy.



RVOT—Right ventricular outflow tract
PV—Pulmonary vein
R—Right coronary cusp (RCC)
N—Non-coronary cusp (NCC)
L—Left coronary cusp (LCC)
LLA—Left atrial appendage
LA—Left atrium
LSPV—Left superior pulmonary vein

Pathology of the aortic valve can be identified as follows:

- Calcification of the aortic valve—suspect aortic stenosis.
- Dilated aortic root with malcoaptation of the aortic valve leaflets in end-diastole—suspect aortic regurgitation.
- Low attenuation masses and aortic root thickening with pseudoaneurysms—consider endocarditis.

Remember to review the valve cusps to determine whether there are three cusps (tricuspid aortic valve) or two cusps (bicuspid aortic valve).

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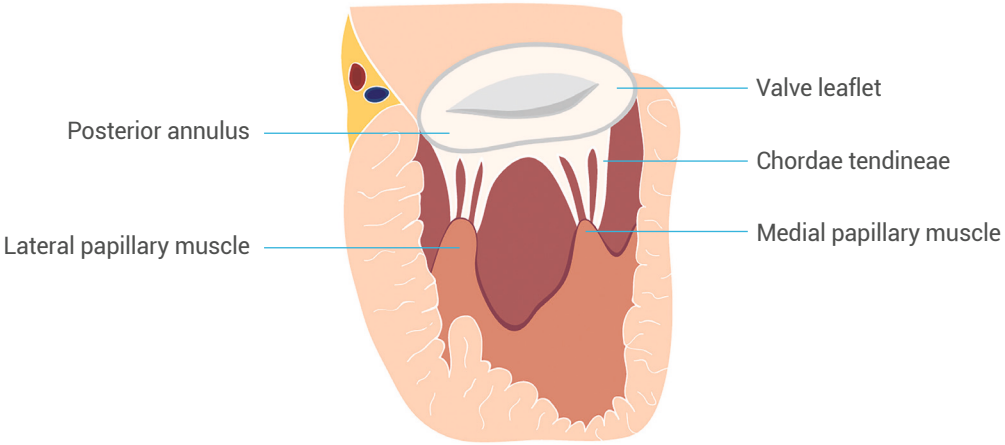
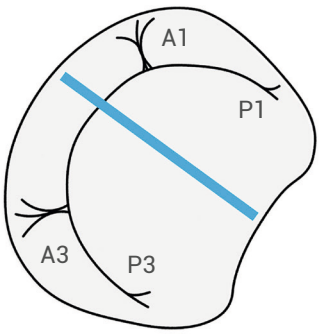
EVALUATING THE MITRAL VALVE

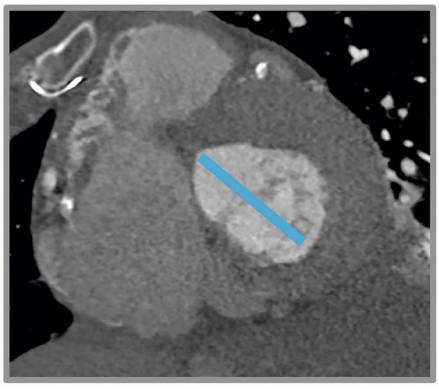
Evaluating the mitral valve is more complex than evaluating the aortic valve since one needs to consider the valve leaflets, the annulus and mitral valve apparatus, as well as papillary muscle, chords, annulus, and left ventricle.



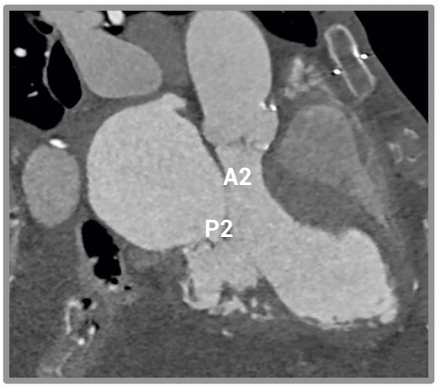
Segmental approach

Using a segmental approach, the mitral valve can be evaluated robustly.





En face



Coronal

If you are uncertain as to which scallops represent A1 and P1, and so on, the anterior leaflet is the one closest to the aortic valve and is more anteriorly located. Secondly, A1 and P1 are the closest scallops to the left atrial appendage, which can serve you as an anatomical landmark.

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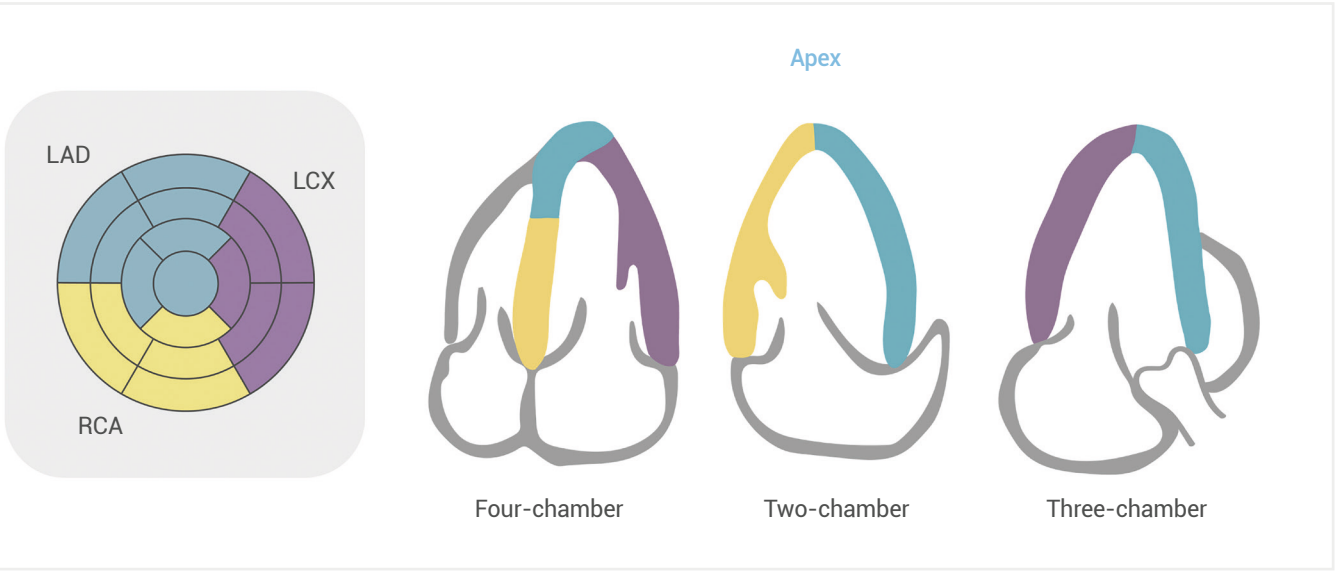
EVALUATING THE LEFT VENTRICLE

The left ventricle can be subdivided into a 16-segment or 17-segment model based on whether the apex is taken as an additional 17th segment.

To create the left ventricular views, place your cross hairs at the center of the mitral valve and align them with the mitral valve annulus and apex in two of the multiplanar views. This will display the short-axis view of the left ventricle.



Various myocardial segments and their normal coronary blood supply

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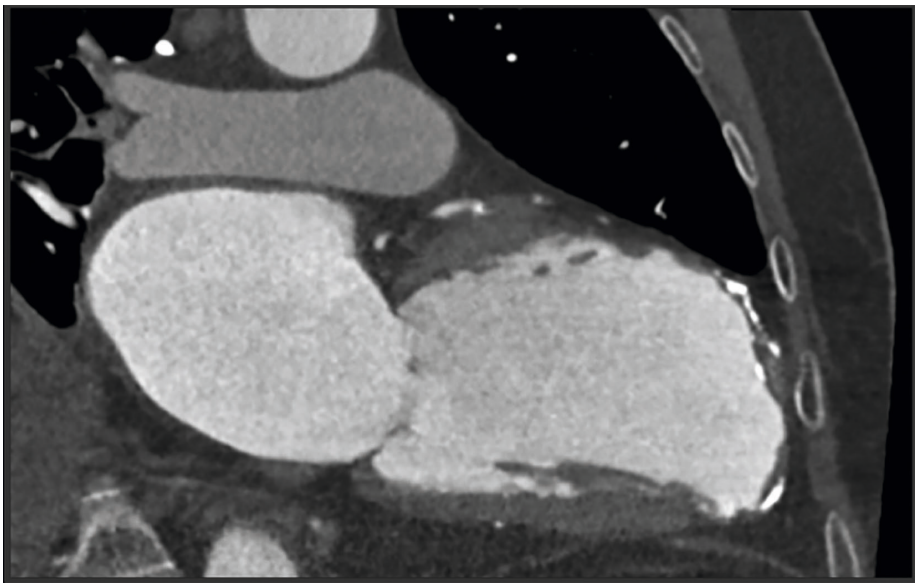
MYOCARDIAL INFARCTION ON CT



Areas of myocardium that are thin, compared to normal adjacent segments, can identify myocardial infarction. On cine imaging these segments will be severely hypokinetic, akinetic, or dyskinetic. Occasionally, the infarcted myocardium becomes replaced with calcium and the dysfunctional segments have superimposed thrombus.

To look for hypoperfusion of the myocardium, change the workstation setting as follows:

- Wide minimal intensity projection (MinIP) image (5 mm)
- Window width: 200
- Window level: 100

Areas of hypoperfusion will then appear black. Note that this technique is also useful for looking for thrombus.

Dysfunctional segments have superimposed thrombus.

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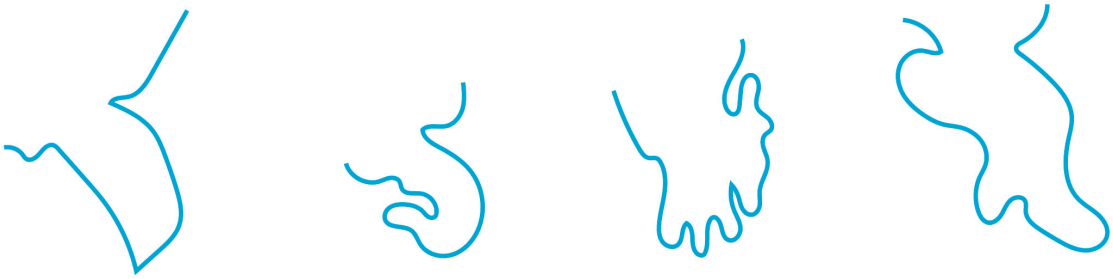
IDENTIFYING THE LEFT ATRIAL APPENDAGE AND VEINS

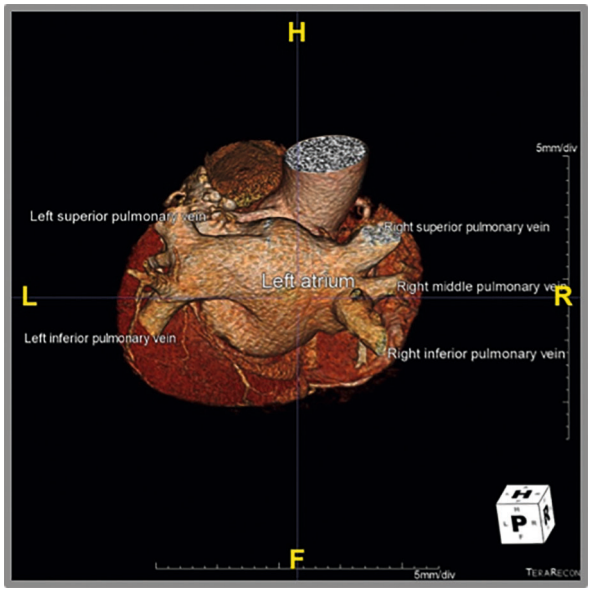
The left atrial appendage (LAA) can be described by various morphological shapes.



Windsock | Chicken wing | Cactus | Cauliflower

When a filling defect is seen in the left atrial appendage, this is only suggestive of thrombus. A further scan is required at 60 seconds, without contrast, to determine whether or not this appearance persists. If it dissipates, the filling defect represents a slow blood flow phenomenon. If it persists, it is likely to represent thrombus.

The pulmonary veins are seen on the following image. There are generally two left-sided and right-sided pulmonary veins. It is not uncommon to have three right-sided pulmonary veins, where the additional vein is called the right middle pulmonary vein. Similarly, it is not unusual to find a common ostium to the left- or right-sided pulmonary veins.



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IDENTIFYING LEFT ATRIAL PATHOLOGY

The left atrium is often a neglected structure but can, on occasion, demonstrate pathological features. It is generally not indicated to measure the size of the left atrium, since measurements should be taken at end-systole (40% of the R-R interval). This phase is not usually available if scanning is being done with ECG-gated prospective acquisitions in mid-diastole. If measurements are made, the following table can be used as a quantitative descriptor for size.

< 20	normal
20–30	mild
30–40	moderate
> 40	severe

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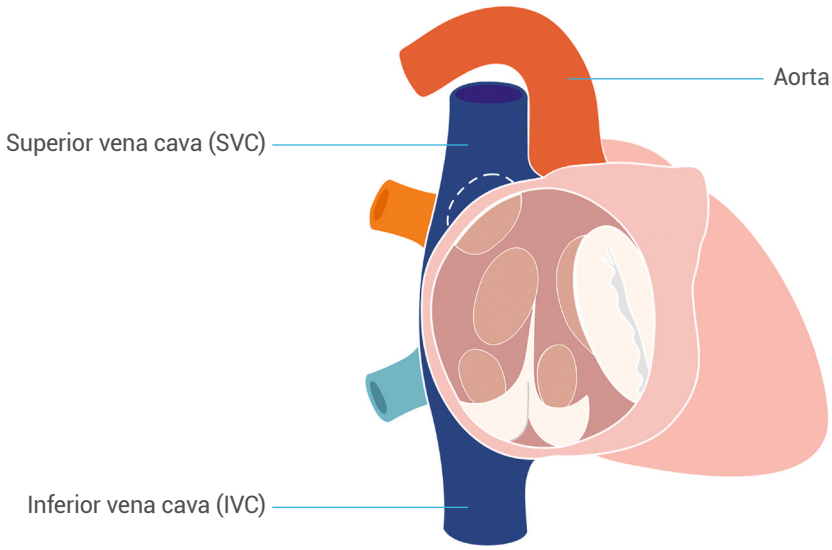
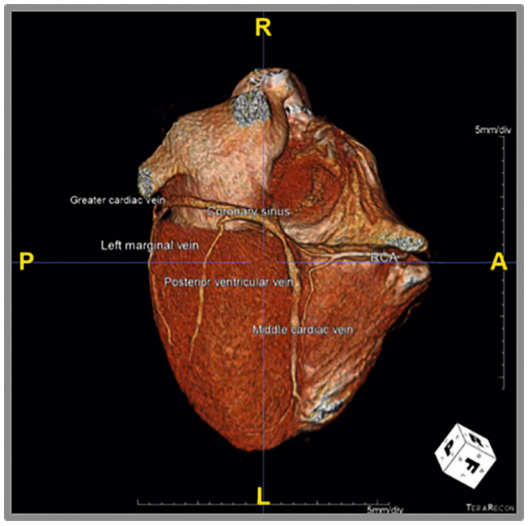
IDENTIFYING THE RIGHT ATRIUM AND CORONARY VENOUS ANATOMY

The anatomy of the right side of the heart can be seen on the image below. The right heart is an important structure to evaluate when cardiomyopathy, valvular heart disease, congenital heart conditions, lung conditions, and CRT therapy are being considered or pacemaker complications have occurred. The right ventricle should be no greater than 2/3 the size of the left ventricle. When it is equal in size or larger at the base at end-diastole, right ventricular enlargement can be said to exist.



The right ventricle has a complex structure and cannot be seen or evaluated in one image alone. Right ventricular and right ventricular outflow tract views should therefore both be looked at, if a right ventricular assessment is required.

The coronary veins drain into the right atrium via the coronary sinus. The anatomy of these can be seen on this image.



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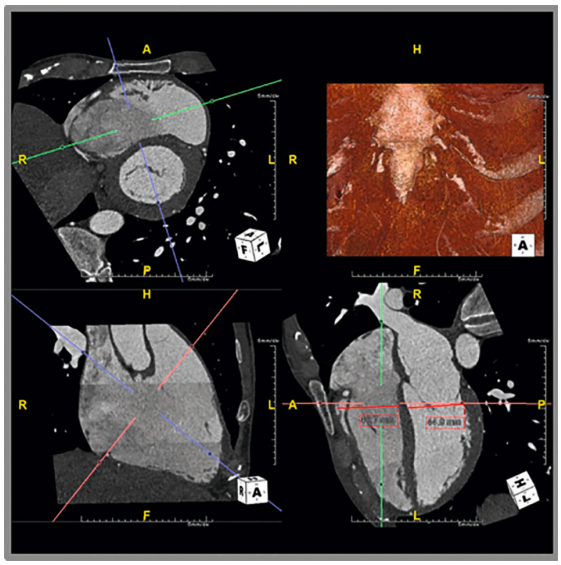
EVALUATING RIGHT HEART ABNORMALITIES

The right ventricle views

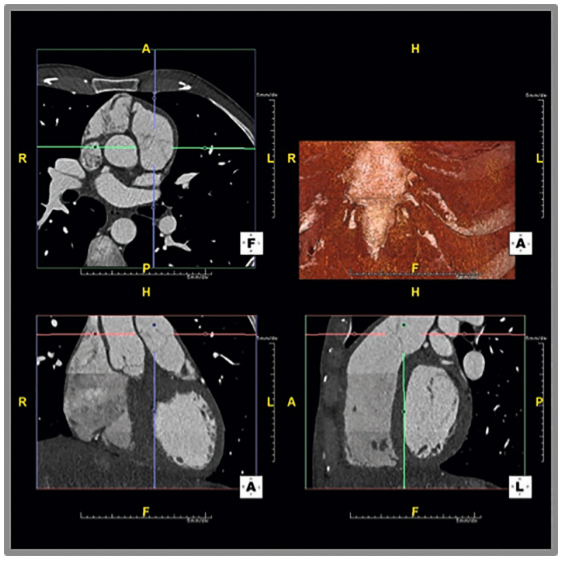
To obtain the right ventricle (RV) views, find the four-chamber view of the left ventricle, then move the crosshairs to the tricuspid valve annulus plane, and aim the cross hairs down the apex (bottom right-hand image).

In the second plane, angle down to the apex of the right ventricle, while maintaining the plane of the tricuspid valve annulus (bottom left-hand image). This brings out the RV views.



The right ventricular outflow tract view

To obtain a view of the right ventricular outflow tract (RVOT), place your crosshairs at the pulmonary valve (top left-hand image) and angle to the right ventricular outflow tract.



READING LIST

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