How to review coronary angiogram before CABG: Normal coronary artery.

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The major vessels of the coronary circulation;

1. the left main coronary that divides into **left anterior descending** and **circumflex**branches
2. the right main coronary artery.

The **left and right coronary arteries** originate at the base of the aorta from openings called the **coronary ostia** located behind the aortic valve leaflets.

Lie on the surface of the heart, and therefore are sometimes referred to as the **epicardial coronary vessels**, and distribute blood flow to different regions of the heart muscle.

When the vessels are not diseased, they have a low vascular resistance relative to their more distal and smaller branches that comprise the microvacular network.

The arterioles branch into numerous capillaries that lie adjacent to the cardiac myocytes. A high capillary-to-cardiomyocyte ratio and short diffusion distances ensure adequate oxygen delivery to the myocytes and removal of metabolic waste products from the cells (e.g., CO_2 and H^+).

Capillary blood flow enters venules that join together to form cardiac veins that drain into the **coronary sinus** located on the posterior side of the heart, which drains into the right atrium.
There are also **anterior cardiac veins** and **thesbesian veins** drain directly into the cardiac chambers.

The regions of the heart that are generally supplied by the different coronary arteries : This anatomic distribution is important because these cardiac regions are assessed by 12-lead ECGs to help localize ischemic or infarcted regions, which can be loosely correlated with specific coronary vessels.

Anatomic Region of Heart	Coronary Artery (most likely associated)
Inferior	Right coronary
Anteroseptal	Left anterior descending
Anteroapical	Left anterior descending (distal)
Anterolateral	Circumflex
Posterior	Right coronary artery

The features of coronary blood flow:

•Flow is tightly coupled to oxygen demand. This is necessary because the heart has a **very high basal oxygen consumption** (8-10 ml O_2/min/100g) and **the highest A-VO_2 difference** of a major organ (10-13 ml/100 ml). In non-diseased coronary vessels, whenever cardiac activity and oxygen consumption increases there is an increase in coronary blood flow (active hyperemia) that is nearly proportionate to the increase in oxygen consumption.

•**Good autoregulation** between 60 and 200 mmHg perfusion pressure helps to maintain normal coronary blood flow whenever coronary perfusion pressure changes due to changes in aortic pressure.

•Adenosine is an important mediator of active hyperemia and autoregulation. It serves as a metabolic coupler between oxygen consumption and coronary blood flow. Nitric oxide is also an important regulator of coronary blood flow.

•Progressive ischemic coronary artery disease results in the growth of new vessels (termed angiogenesis) and **collateralization** within the myocardium. Collateralization increases myocardial blood supply by increasing the number of parallel vessels, thereby reducing vascular resistance within the myocardium.

•Extravascular compression (shown to the right) during systole markedly affects coronary flow; therefore, most of the coronary flow occurs during diastole. Because of extravascular compression, the endocardium is more susceptible to ischemia especially at lower perfusion pressures. Furthermore, with tachycardia there is relatively less time available for coronary flow during diastole to occur – this is particularly significant in patients with coronary artery disease where coronary flow reserve (maximal flow capacity) is reduced.

•Activation of sympathetic nerves innervating the coronary vasculature causes only transient vasoconstriction mediated by α_1-adrenoceptors. This brief (and small) vasoconstrictor response is followed by vasodilation caused by enhanced production of vasodilator metabolites (active hyperemia) due to increased mechanical and metabolic activity of the heart resulting from β_1-adrenoceptor activation of the myocardium. Therefore, sympathetic activation to the heart results in coronary vasodilation and increased coronary flow due to increased metabolic activity (increased heart rate, contractility) despite direct vasoconstrictor effects of sympathetic activation on the coronaries. This is termed "functional sympatholysis."

•Parasympathetic stimulation of the heart (i.e., vagal nerve activation) elicits modest coronary vasodilation (due to the direct effects of released acetylcholine on the coronaries). However, if parasympathetic activation of the heart results in a significant decrease in myocardial oxygen demand due to a reduction in heart rate, then intrinsic metabolic mechanisms will increase coronary vascular resistance by constricting the vessels.

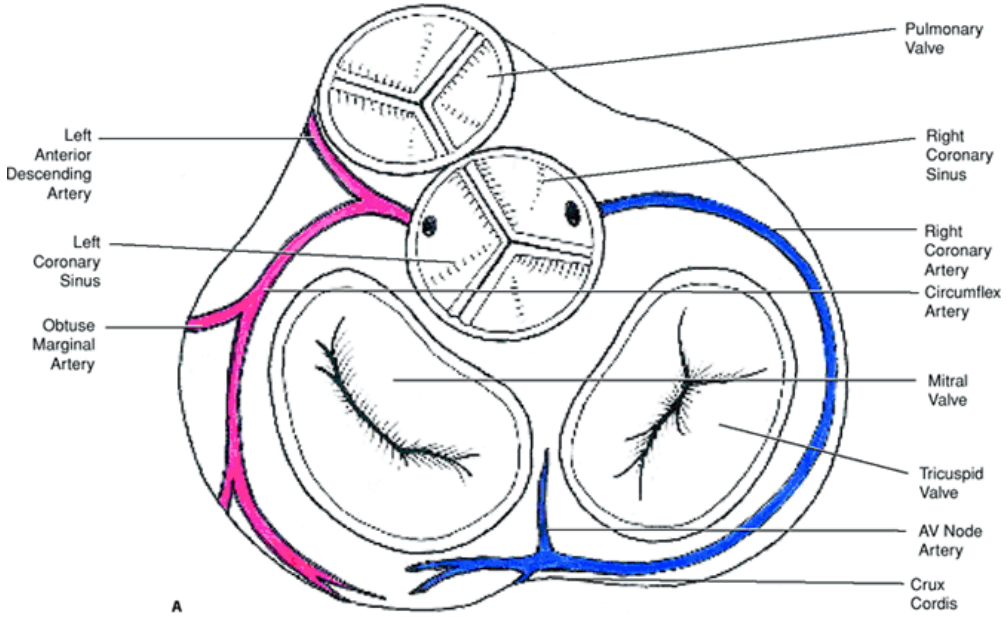
In the presence of **coronary artery disease**, coronary blood flow may be reduced. → increase oxygen extraction from the coronary blood and decrease the venous oxygen content. → leads to tissue hypoxia and angina.

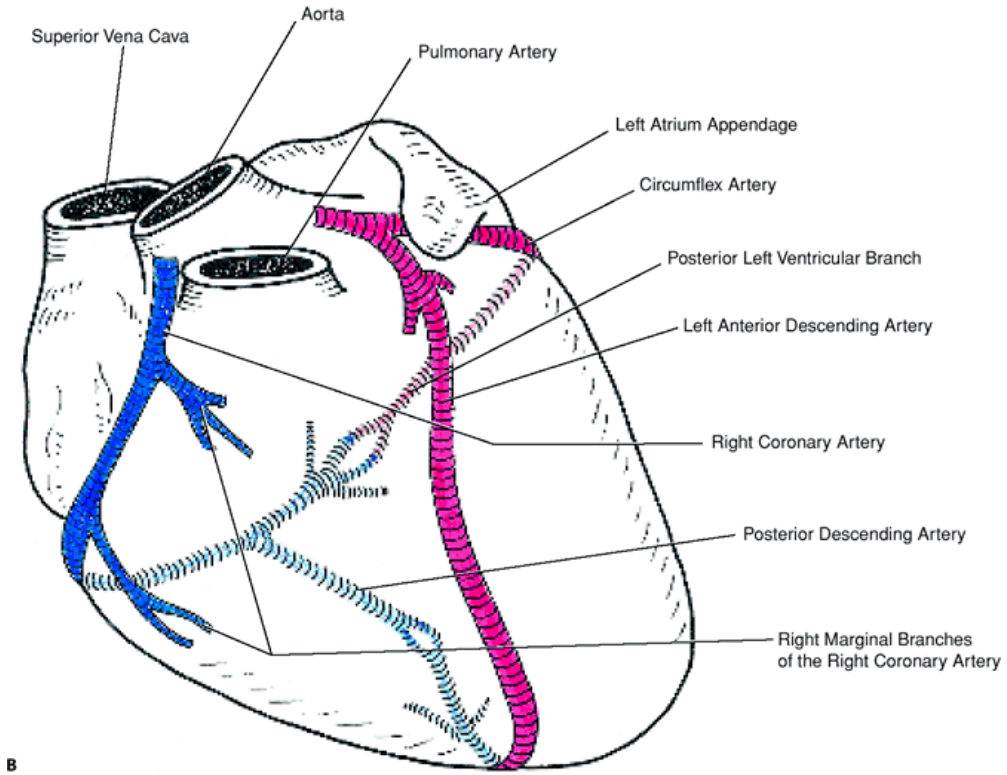
If the lack of blood flow is due to a fixed stenotic lesion in the coronary artery (because of atherosclerosis), blood flow can be improved within that vessel by
1) placing a stent within the vessel to expand the lumen,
2) using an intracoronary angioplasty balloon to stretch the vessel open, or
3) bypassing the diseased vessel with a vascular graft.

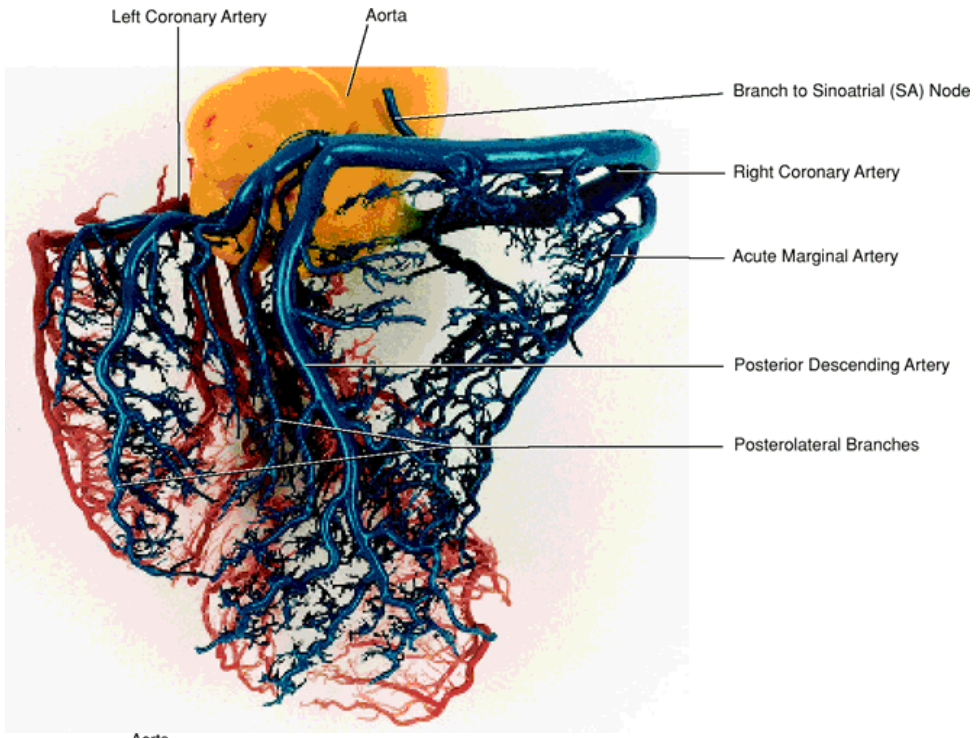
If the insufficient blood flow is caused by a blood clot (thrombosis), a thrombolytic drug that dissolves clots may be administered. Anti-platelet drugs and aspirin are commonly used to prevent the reoccurrence of clots. If the reduced flow is due to coronary vasospasm, then coronary vasodilators can be given (e.g., nitrodilators, calcium-channel blockers) to reverse and prevent vasospasm.

Relationships of the coronary arteries around the heart.

A, The left coronary artery is in red and the right coronary artery is in blue.
B, The right coronary artery and the circumflex arteries form a circle around the atrioventricular sulci. The left anterior descending and the posterior descending arteries form a semicircle around the interventricular sulci.

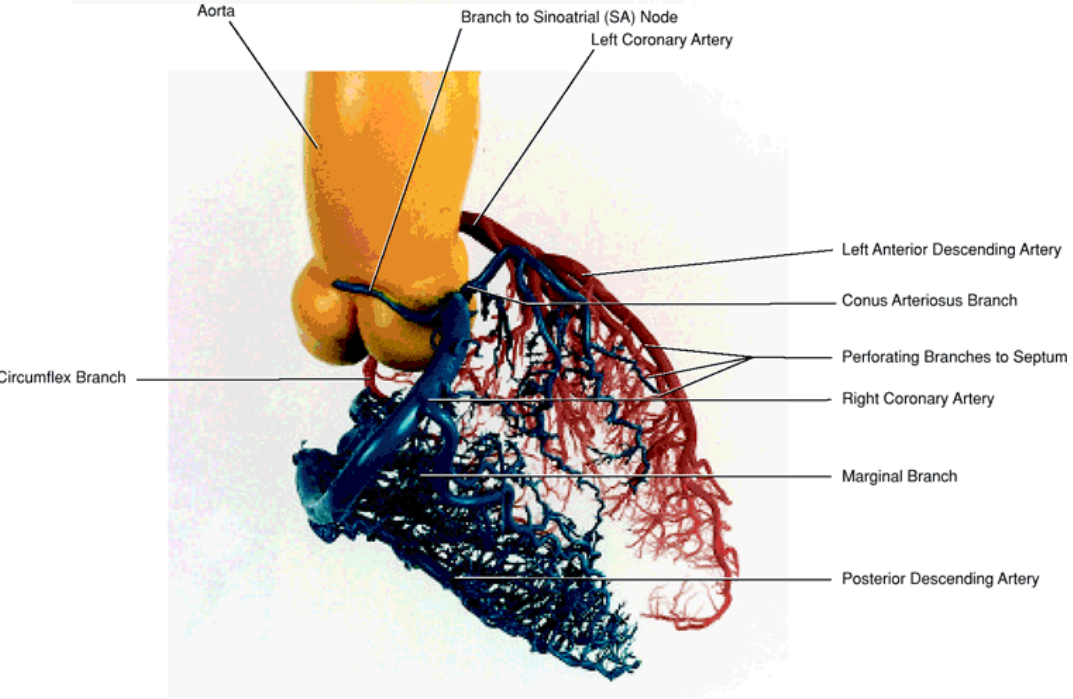






Cast of the coronary arteries viewed from the inferior face of the heart.

The right coronary artery is in blue. It is dominant and supplies all the inferior wall and part of the left lateral wall of the heart. The aorta is in yellow. The left coronary artery is in red.



Cast of the coronary arteries in lateral view.

The right coronary artery is in blue. The left coronary branches are in red and supply the anterior part of the left lateral wall of the heart.

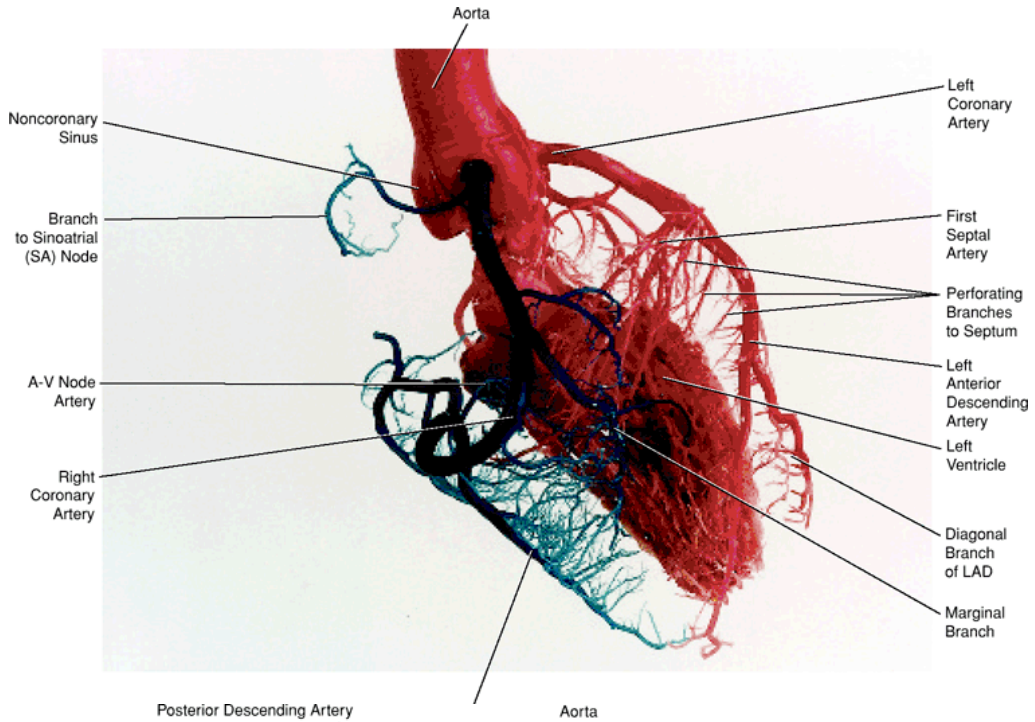


Figure 13.38. Cast of the coronary arteries in right oblique view and their relationships with the left ventricle. The right coronary artery is in blue and gives rise to the posterior descending artery, which extends toward the apex of the heart close to the distal portion of the left anterior descending artery (in red).

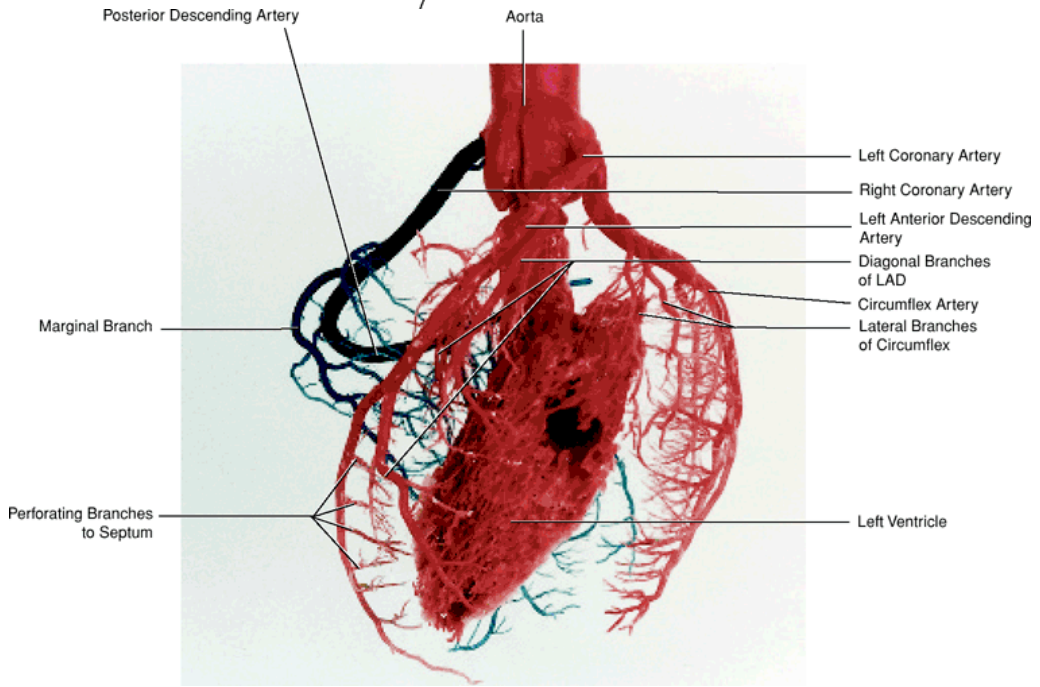


Figure 13.39. Cast of the coronary arteries in a left oblique view and their relation with the left ventricle. The left coronary artery and its branches are in red. The right coronary artery is in blue. LAD, left anterior descending.

The left main coronary artery : variable length and a diameter ranging from 5 to 10 mm.
In about 1% of the hearts studied in a series, there was no left main coronary artery and two orifices were found in the left coronary sinus, with the left anterior descending and circumflex arteries originating separately from each one.

The left main coronary artery bifurcates into two vessels:
- the left anterior descending (LAD): running over the anterior interventricular sulcus
- the circumflex artery related to the left atrioventricular sulcus.

The left main coronary artery in a few cases may give rise to a third vessel: the intermediary artery, also called diagonalis artery, which is located between the LAD and circumflex artery and supplies the free lateral wall of the left ventricle.

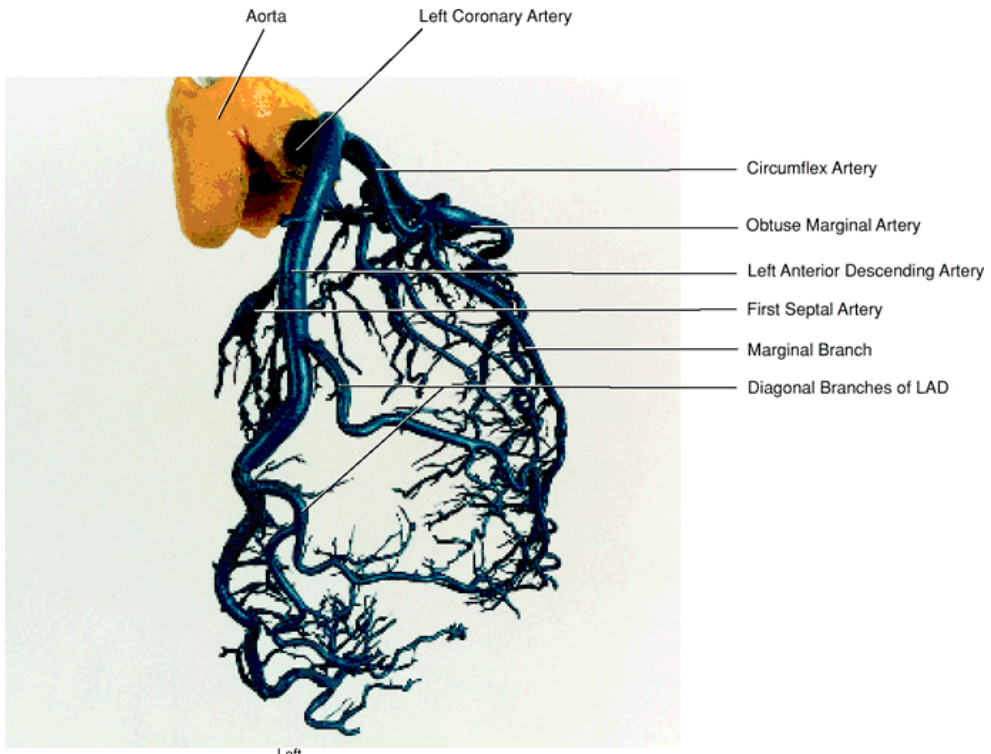
The LAD extends down ending proximal, at or distal to the apex. In this last situation, the LAD goes up into the posterior interventricular sulcus. The length of the LAD is thus extremely variable.

The main branches of the LAD are the diagonal and septal branches.

1. The diagonals vary in number and size. These vessels arise in an acute angle from the LAD and supply the anterolateral wall of the left ventricle. Most frequently, there is a major artery, which is identified as the first diagonal branch.

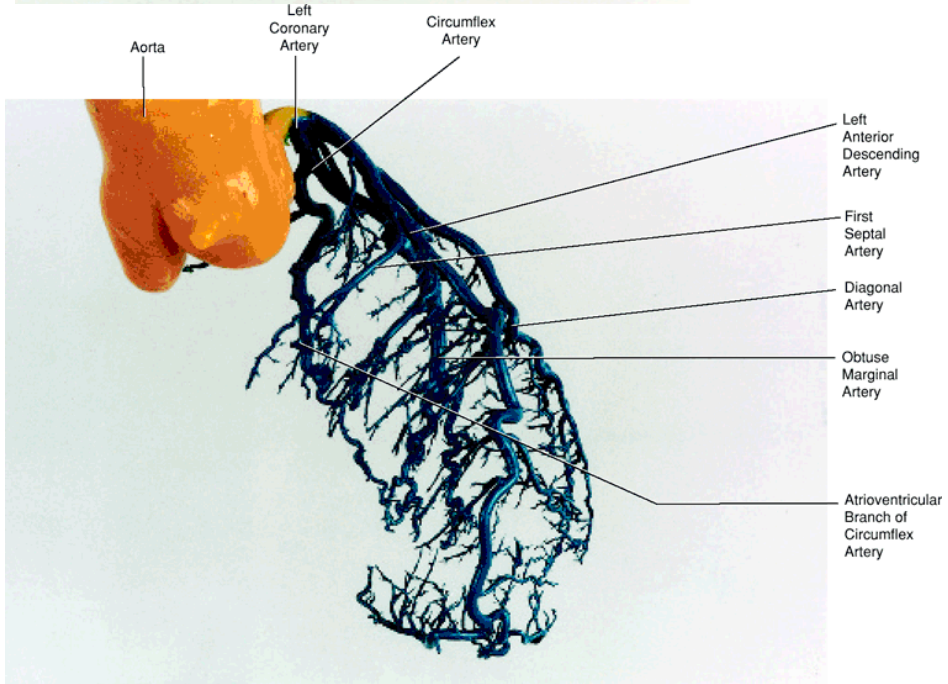
2. The septal branches in number of four to six, or more, originate from the LAD in right angle, coursing close to the endocardium on the right side of the interventricular septum. They anastomose with the septal branches coming from the posterior descending artery. In the majority of hearts, it is possible to identify a bigger septal branch called the first septal artery, originating from the proximal portion of the LAD.

In some hearts, the LAD has an unusual configuration: it is short and divided into two parallel vessels called “dual” LAD. One vessel running over the interventricular sulcus gives off the septal branches and the other, lying in the anterior left ventricular wall, originates the diagonal branches.



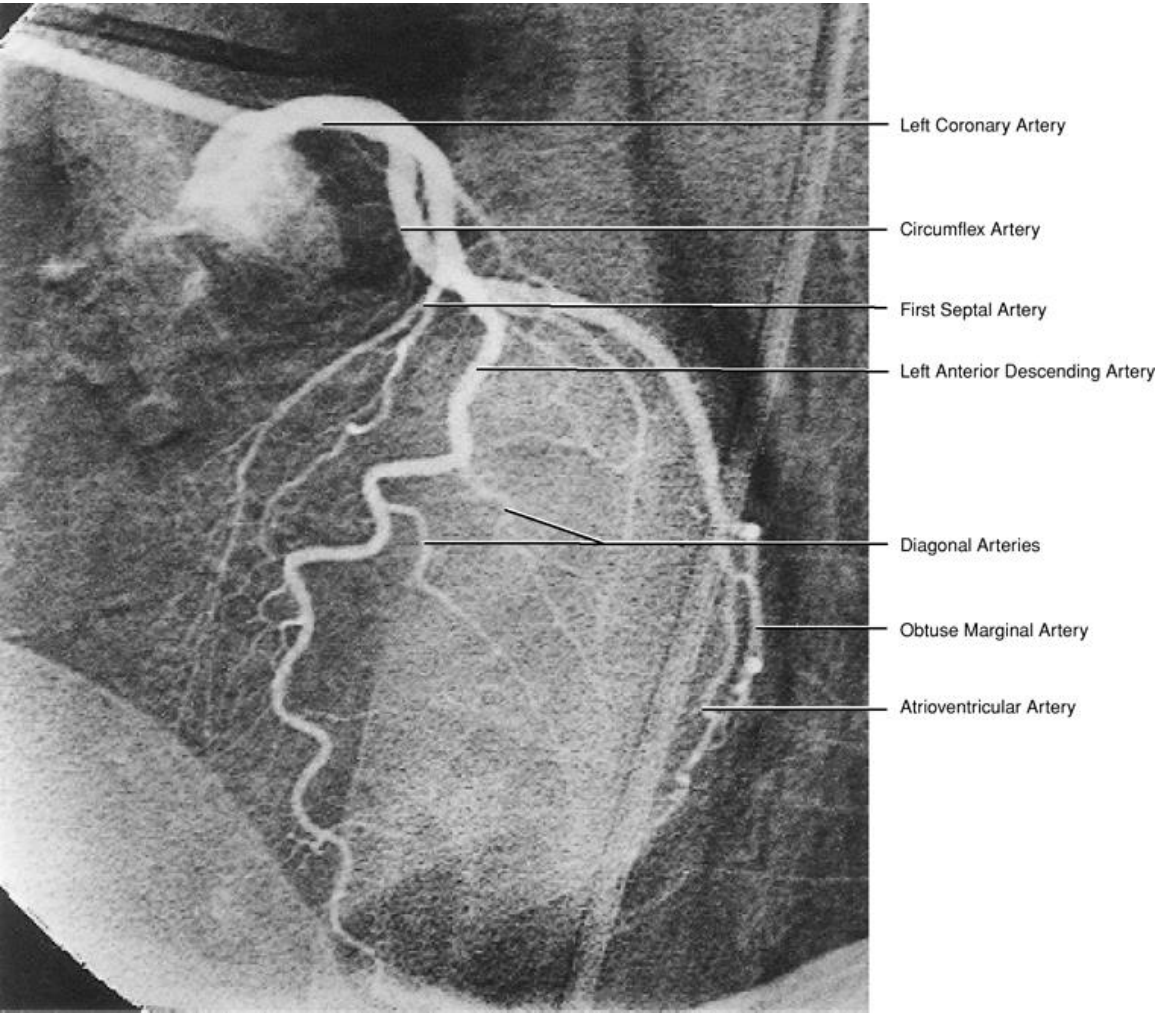
Cast of the left coronary artery in a left oblique view.

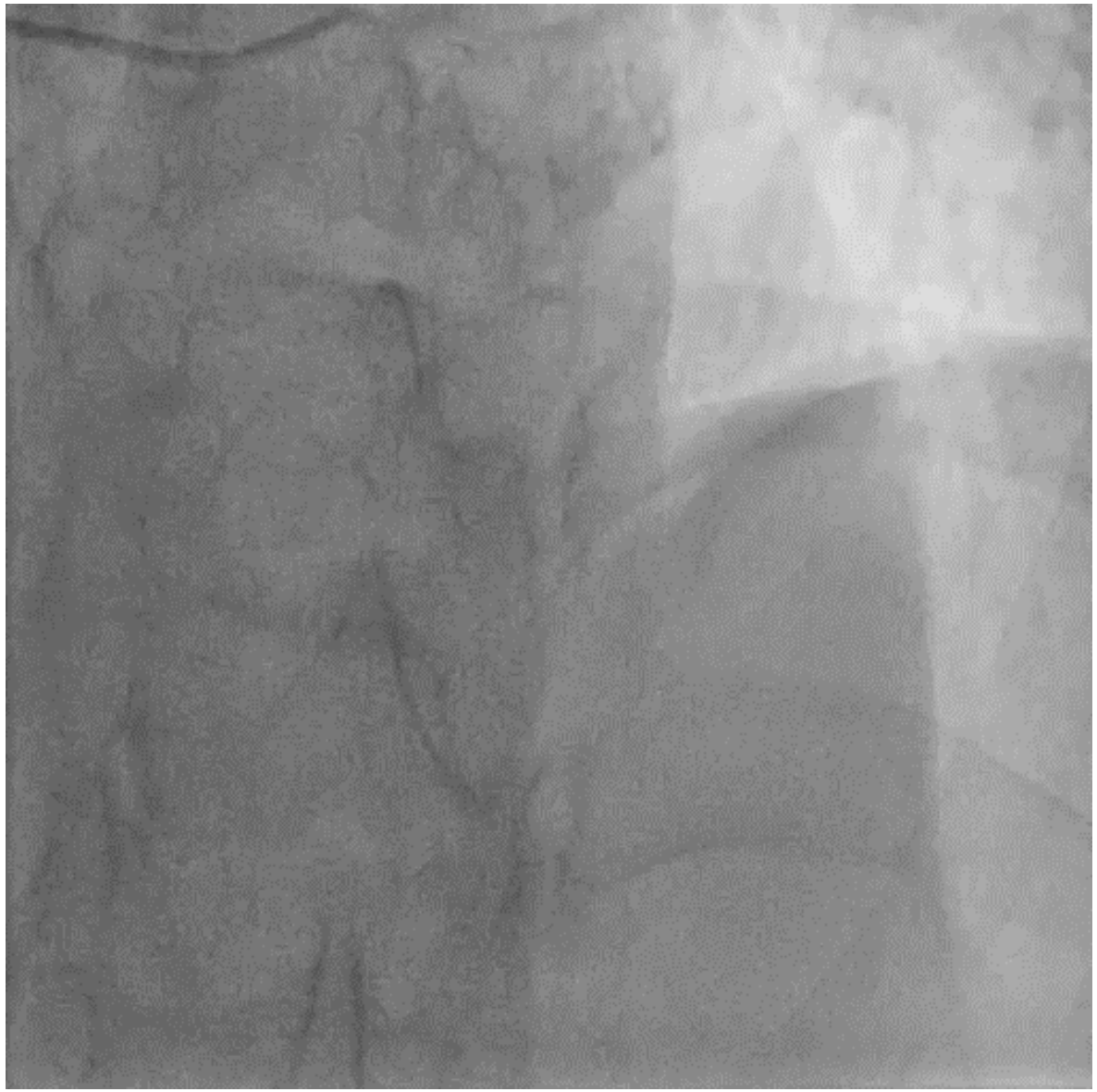
The coronary artery is in blue and the aorta is in yellow.



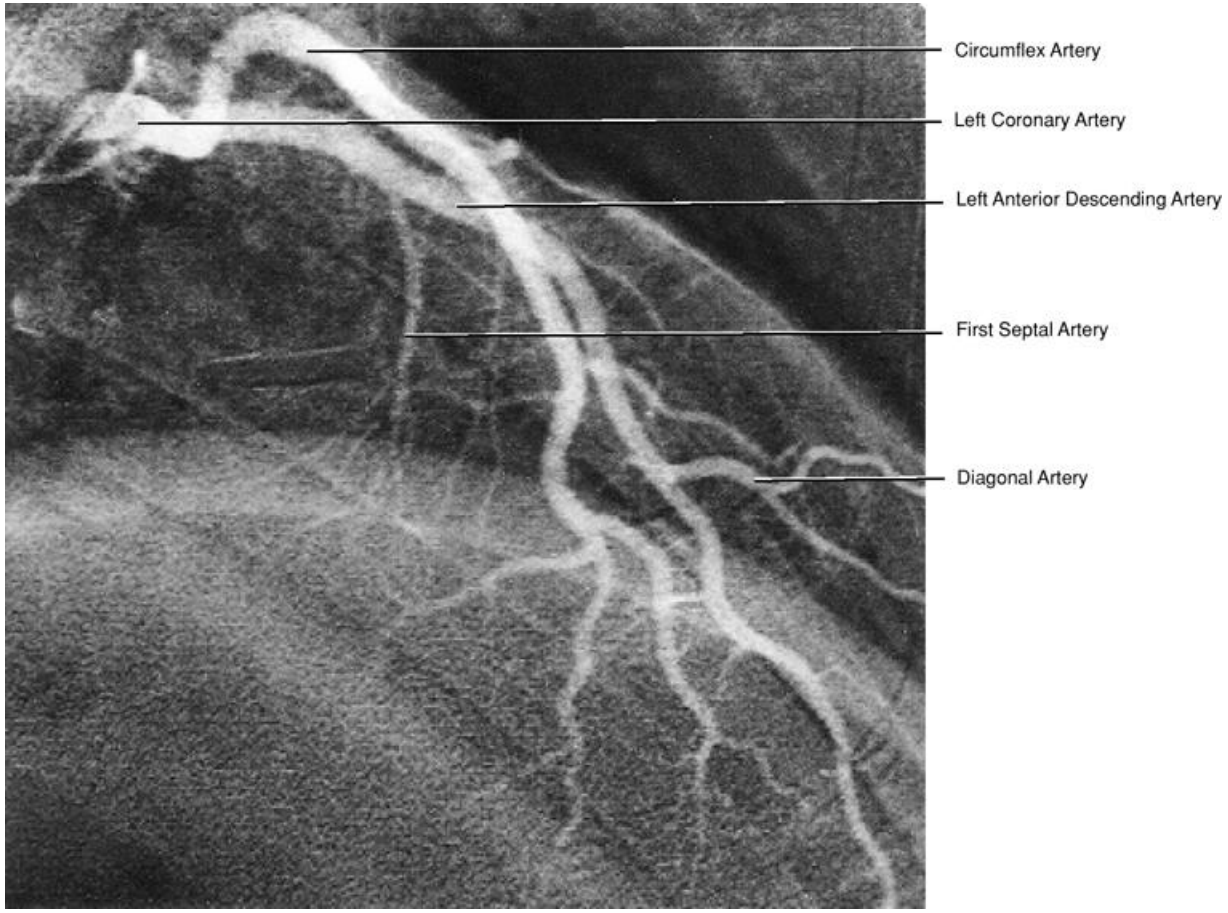
Cast of the left coronary artery in a right oblique view.

The coronary artery is in blue and the aorta is in yellow.

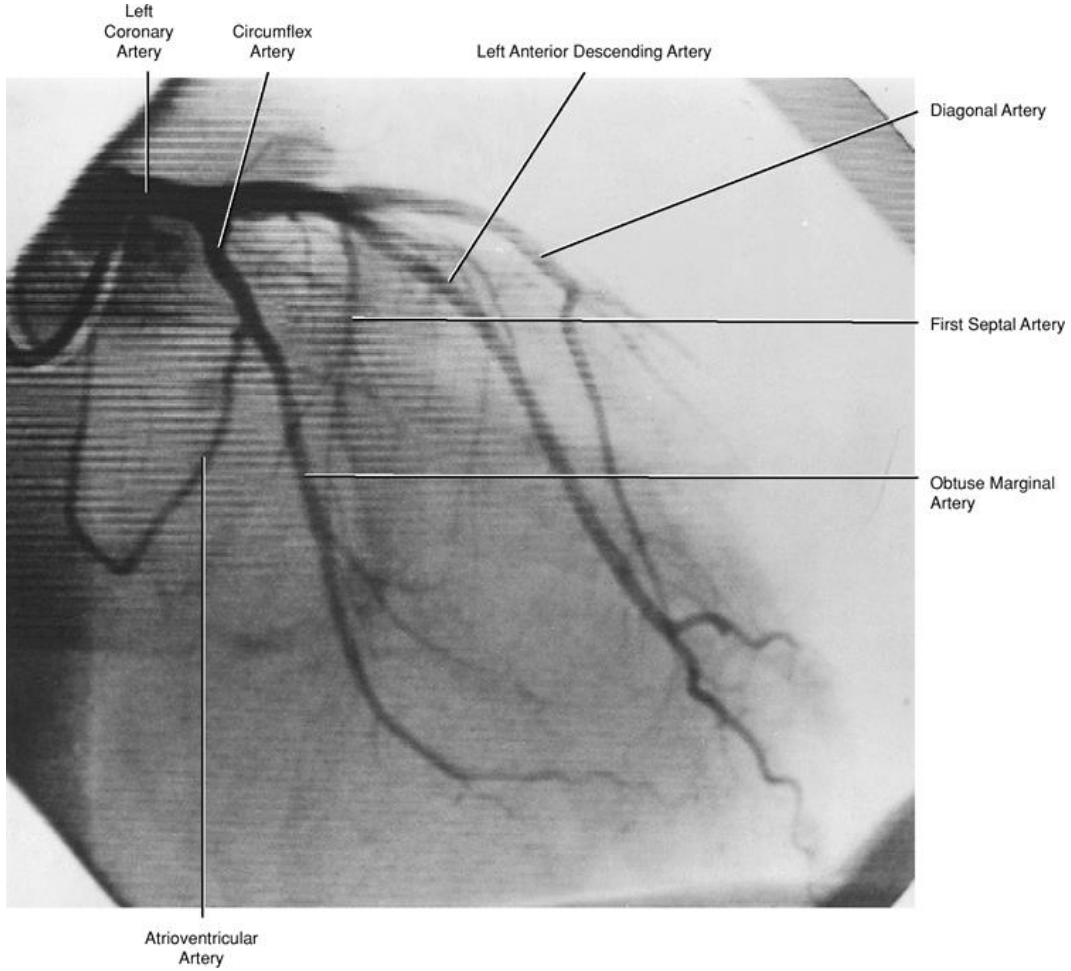


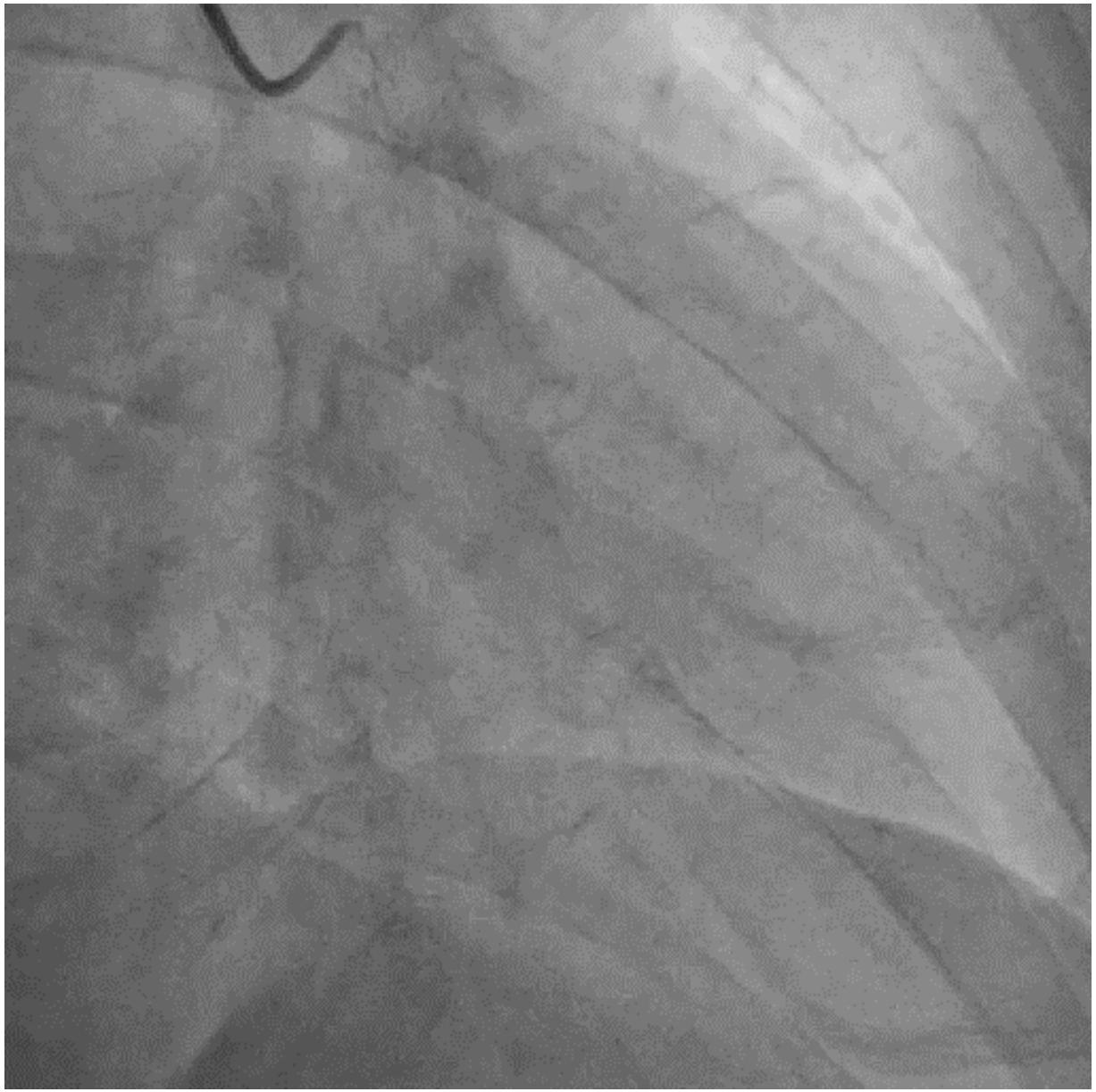


Angiogram of the left coronary artery in the cranial left anterior oblique projection.

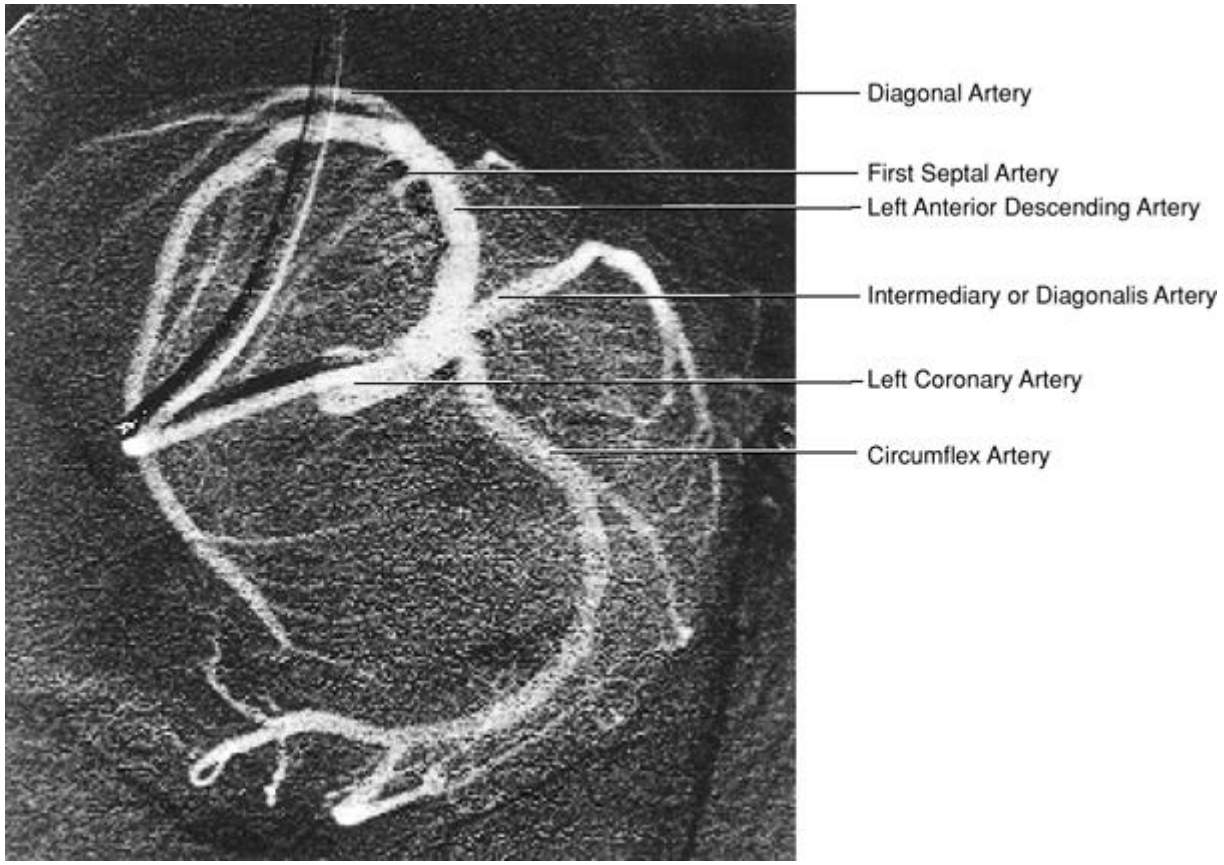


Angiogram of the left coronary artery in the cranial right anterior oblique view. The origin of the septal and diagonal arteries is well demonstrated in this projection.

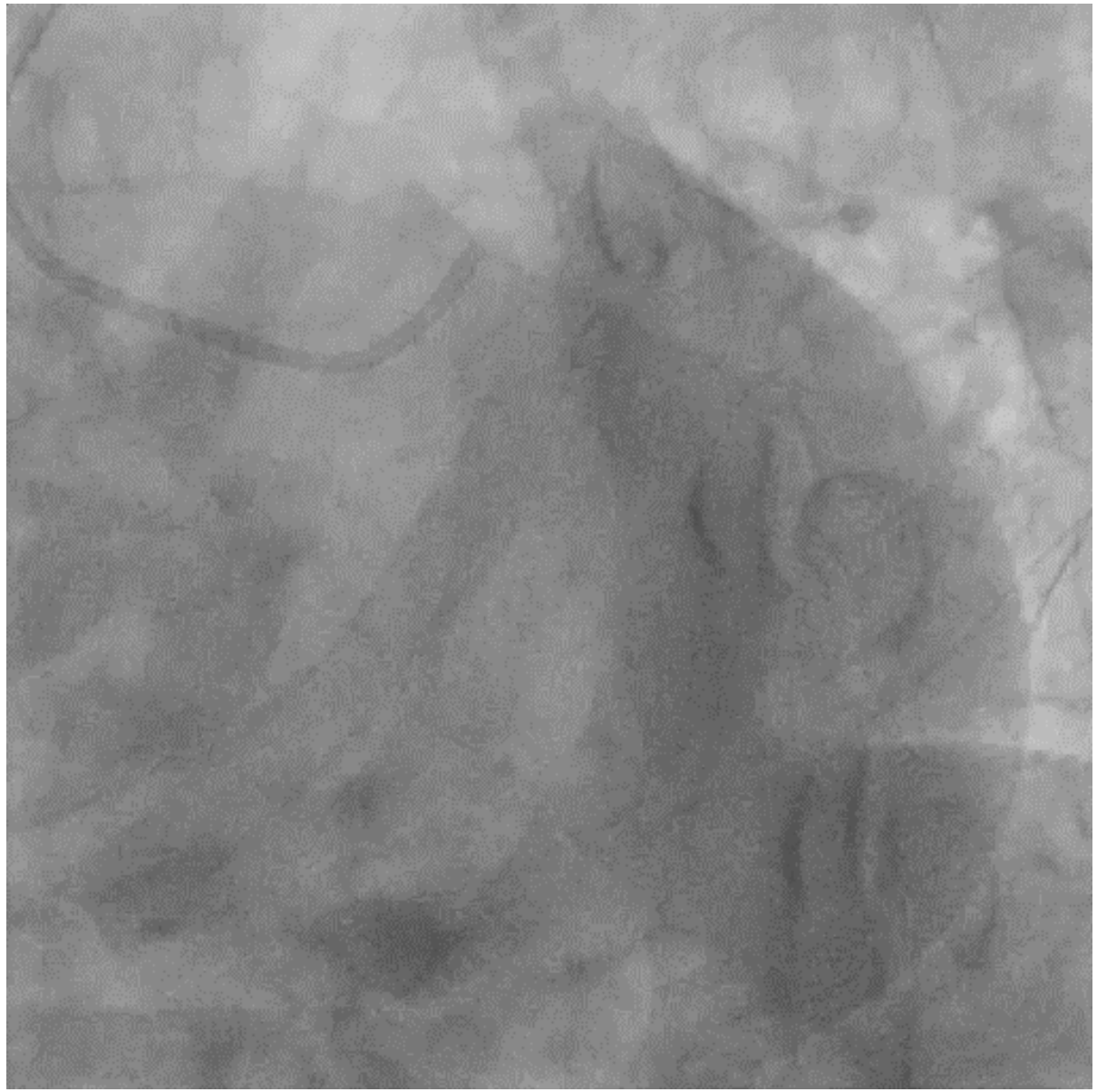




Angiogram of the left coronary artery in the right anterior oblique view.



Left coronary artery angiogram obtained in the caudal left anterior oblique or spider projection showing the origin of the left anterior descending artery, the circumflex artery, and the diagonal branch.



The circumflex artery is the other principal vessel originating from the left main coronary artery.

It emerges in a right or acute angle and is covered by the left atrial appendage in its proximal portion, and then takes position in the left atrioventricular sulcus. The circumflex artery may terminate proximal to the obtuse margin of the left ventricle, before, at, or beyond the crux cordis.

The principal branches of the circumflex artery are the marginal arteries and the left atrial branch.

In 40% of hearts, the sinus node artery arises from the circumflex artery.

The marginal arteries are variable in number, but are usually three. The most prominent marginal artery runs on the obtuse margin of the heart and extends distally close to the apex. When the circumflex artery reaches the crux cordis, it gives origin to the posterior descending and to the atrioventricular node arteries.

The right coronary artery has its origin at the right coronary aortic sinus.

Often a small branch may arise directly from the aortic sinus in an isolated ostium and supply the right ventricle infundibulum. This branch is called the conus artery, which anastomoses with a left conus branch coming from the left coronary artery to form the arterial anulus of Vieussens.

The right coronary artery gives rise to the sinus node artery in 60% of hearts.

The right coronary artery goes into the right atrioventricular sulcus and has a variable form of termination. If it is a short artery, it terminates between the acute margin of the right ventricle and the crux cordis as a small branch (left dominance).

When there is a dominant right coronary artery, it extends further from the crux, supplying the posterolateral wall of the left ventricle with a variable number of posterolateral branches.

The right coronary artery gives origin to the right marginal or acute marginal artery that supplies the free anterior wall of the right ventricle. The shorter the left circumflex artery, the longer will be the terminal posterolateral branches of the right coronary artery. At the crux cordis, the right coronary gives origin to the posterior descending artery, which runs into the posterior interventricular sulcus and supplies the inferior portion of the interventricular septum through a variable number of septal branches. Several of these small septal branches anastomose with the septal branches coming from the anterior descending artery. Just distal to the crux, the right coronary artery makes an inverted “U” turn, giving origin to the atrioventricular node artery.

Angiographic Aspects

All the details of the lesions as well as their locations should be properly defined. To reach these goals, several angiographic projections are used.

Because the anatomic aspects of the coronary arteries are variable, a number of appropriated projections with special angles of the x-ray beam are used for each different individual. All the principal vessels must be visualized in at least two orthogonal projections.

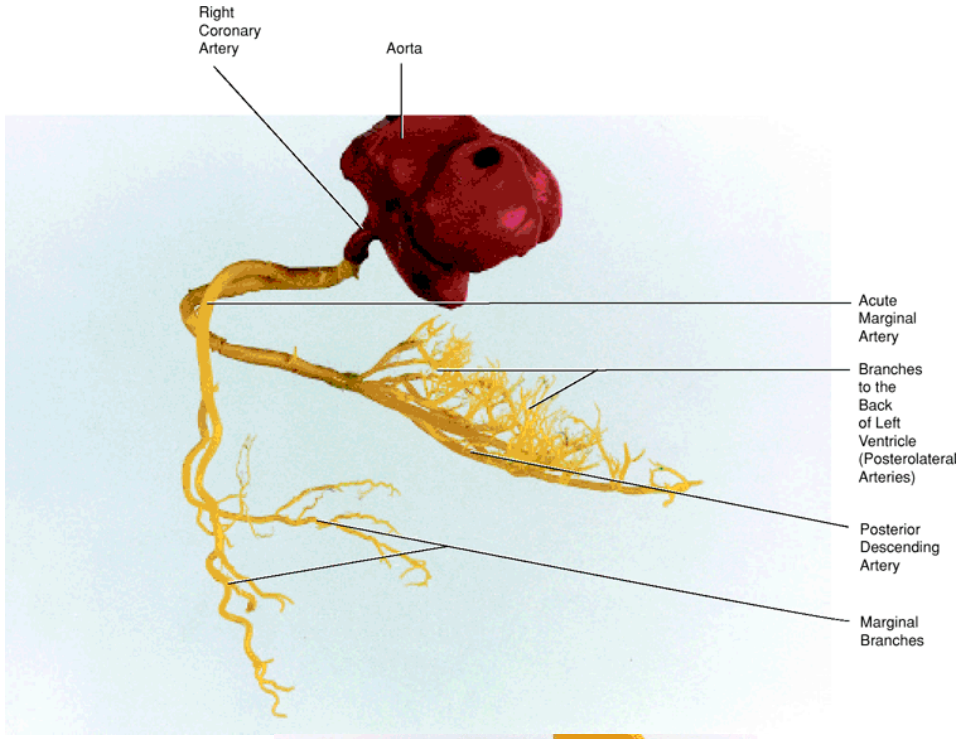
The elongated or cranial left oblique view shows the left main coronary artery, the LAD, and the diagonal branches. The caudal left oblique projection (spider view) shows the left main coronary artery, its bifurcation, and the proximal circumflex artery.

To visualize the LAD, the septal and the diagonal branches, either the cranial or the caudal right oblique views are indicated. The circumflex artery and its marginal branches are well defined in the elongated left oblique and in the caudal right anterior oblique projections.

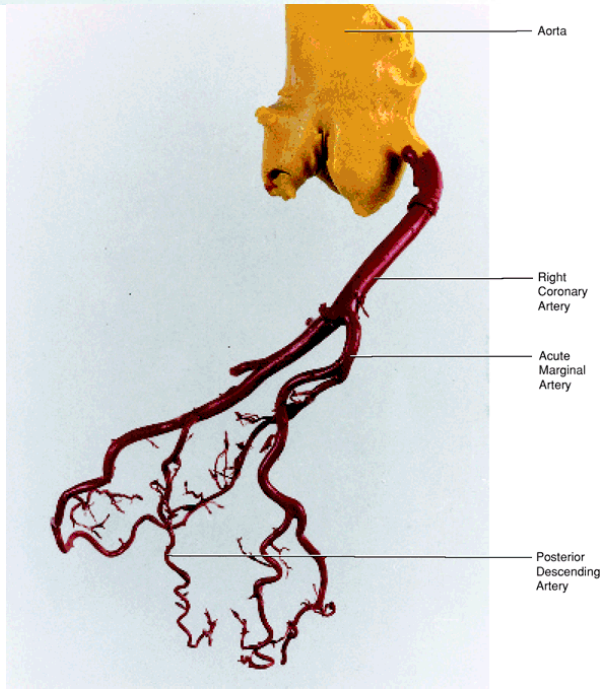
The anteroposterior view is a good projection to study the left main coronary artery and its bifurcation. In some cases, the caudal anteroposterior or the true lateral views may help visualize the proximal portion of the LAD and of the circumflex artery.

The right coronary artery is well visualized in the majority of the cases in the conventional right and left oblique projections .

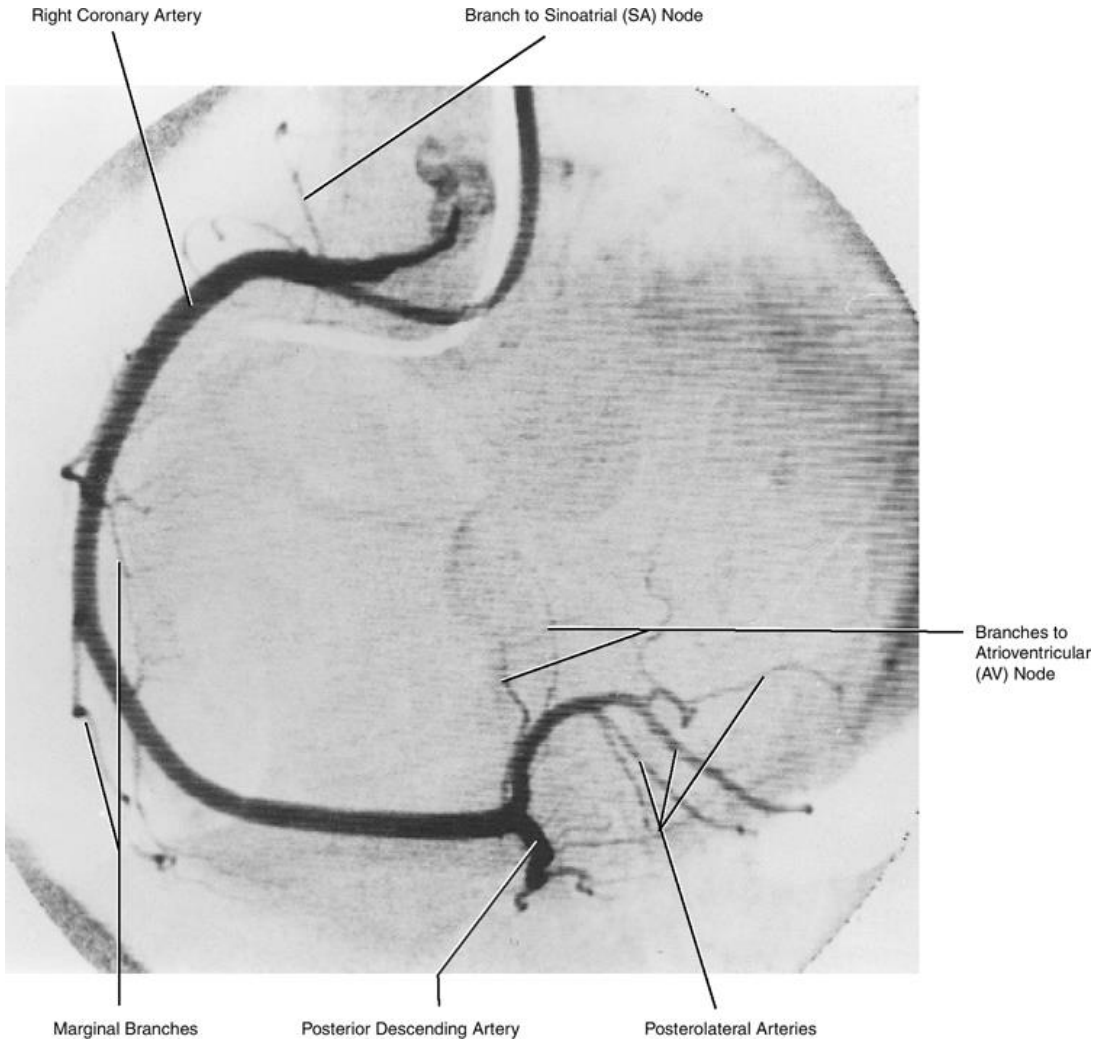
The origin of the posterior descending and the posterolateral branches are defined in the caudal left anterior oblique view.



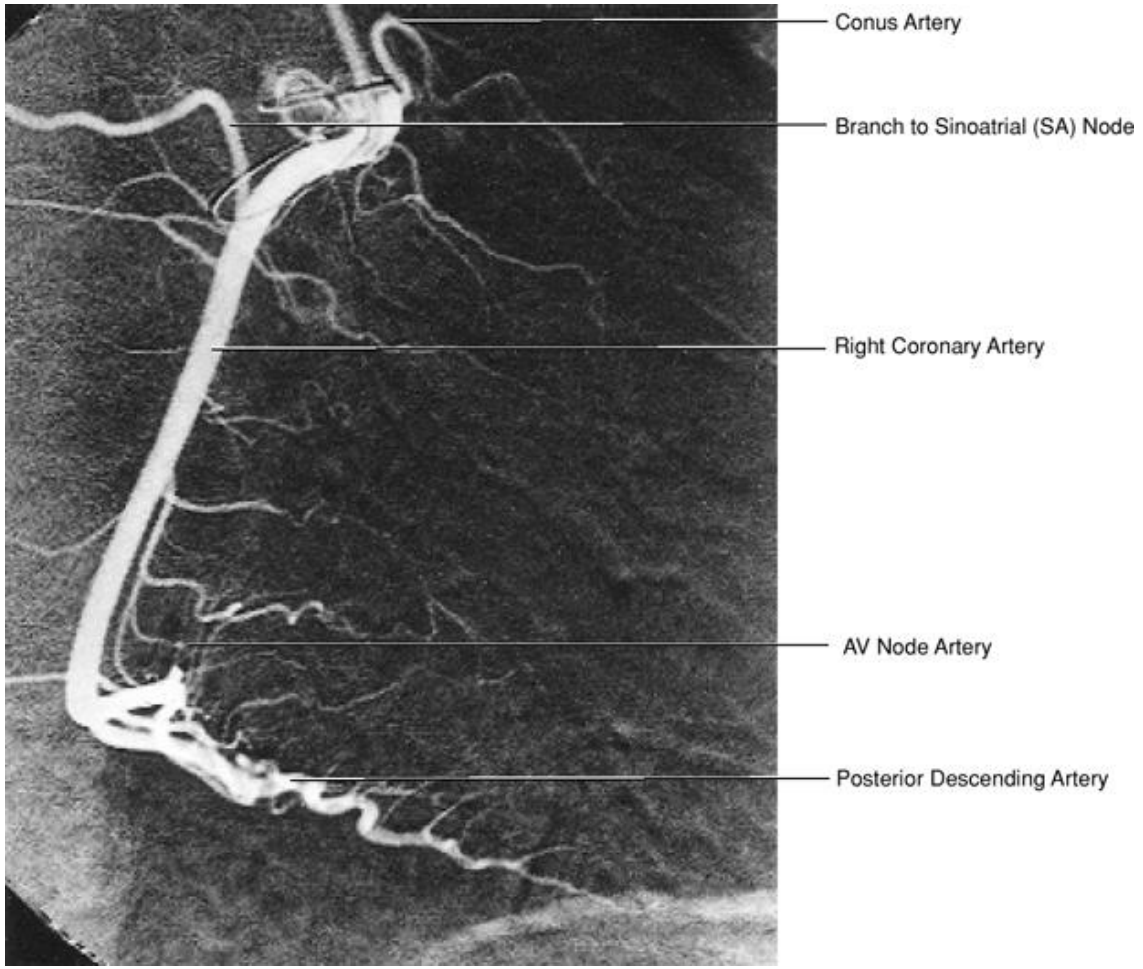
Cast of the right coronary artery in a left oblique view.

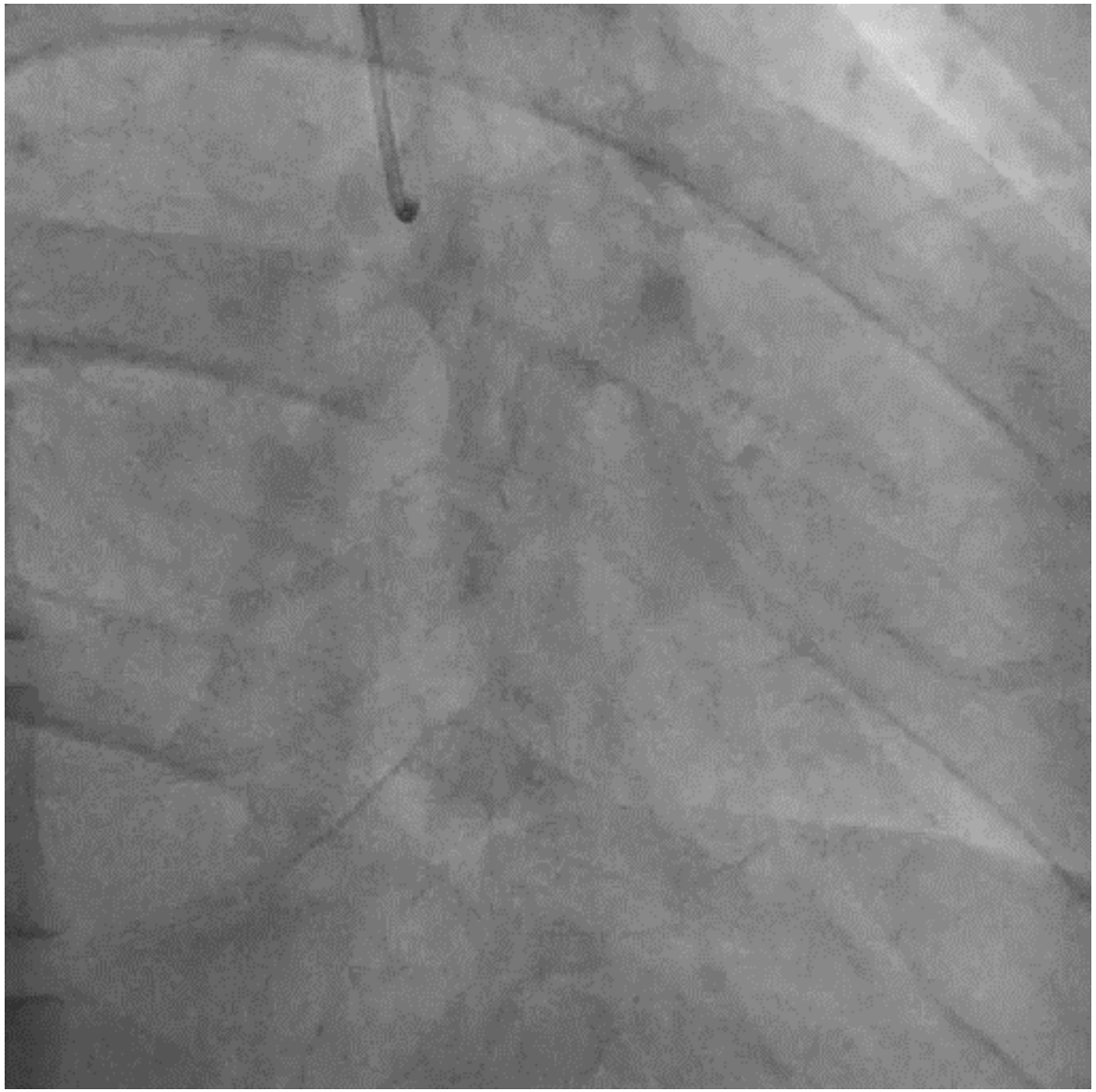


Cast of the right coronary artery in a right oblique view.

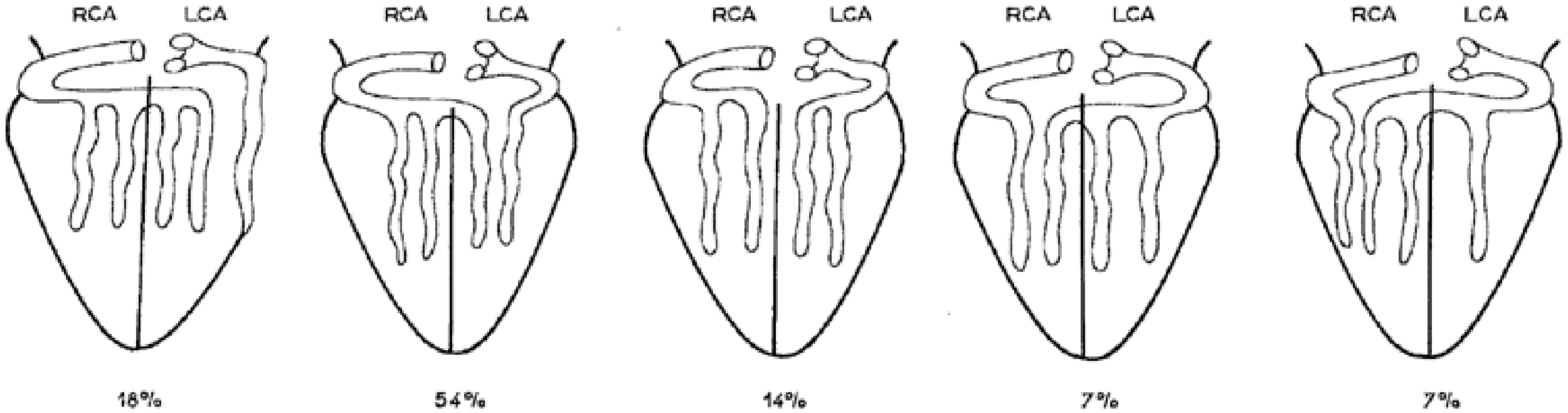


Angiogram of the right coronary artery in the left anterior oblique projection. The branches to the AV node are multiple.





Angiogram of the right coronary artery in the right anterior oblique projection.
Dominant right coronary artery in the left anterior oblique view. The posterior descending artery arises from the right coronary artery at the crux cordis.



Distribution of the coronary branches to the posterior surface of the heart.
(According to Campbell 1929).

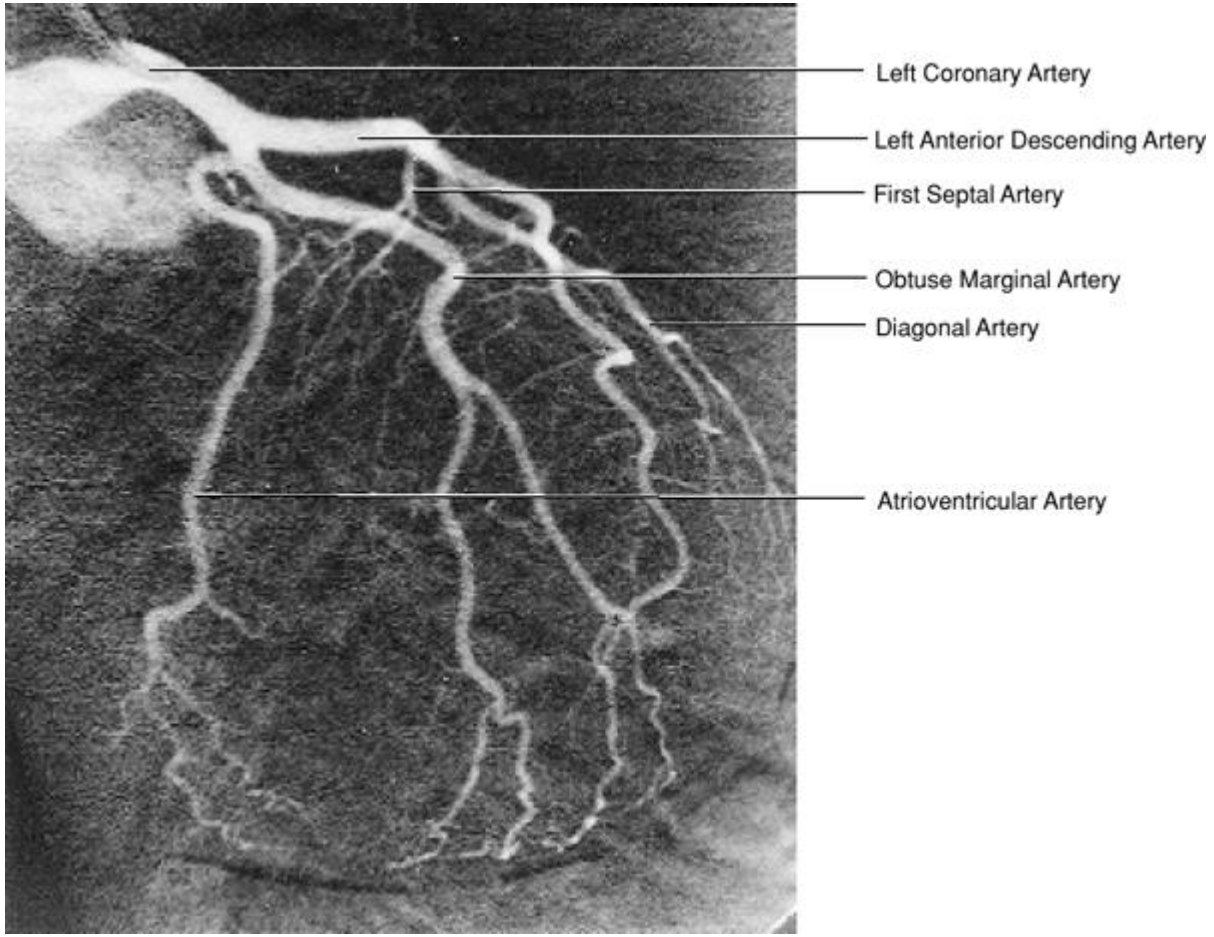


Figure 13.52. Left coronary artery angiogram in the caudal right anterior oblique projection. The circumflex artery is short and divides into a well-developed obtuse marginal artery and an atrioventricular artery.

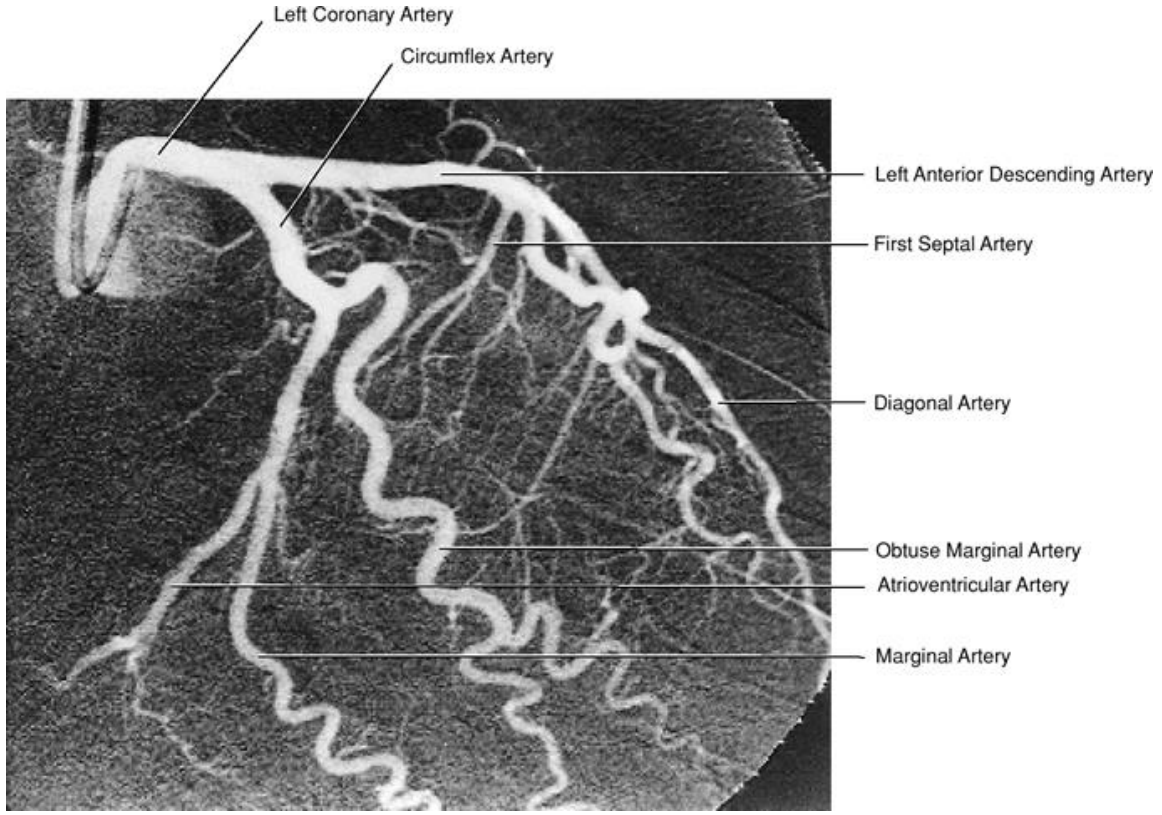
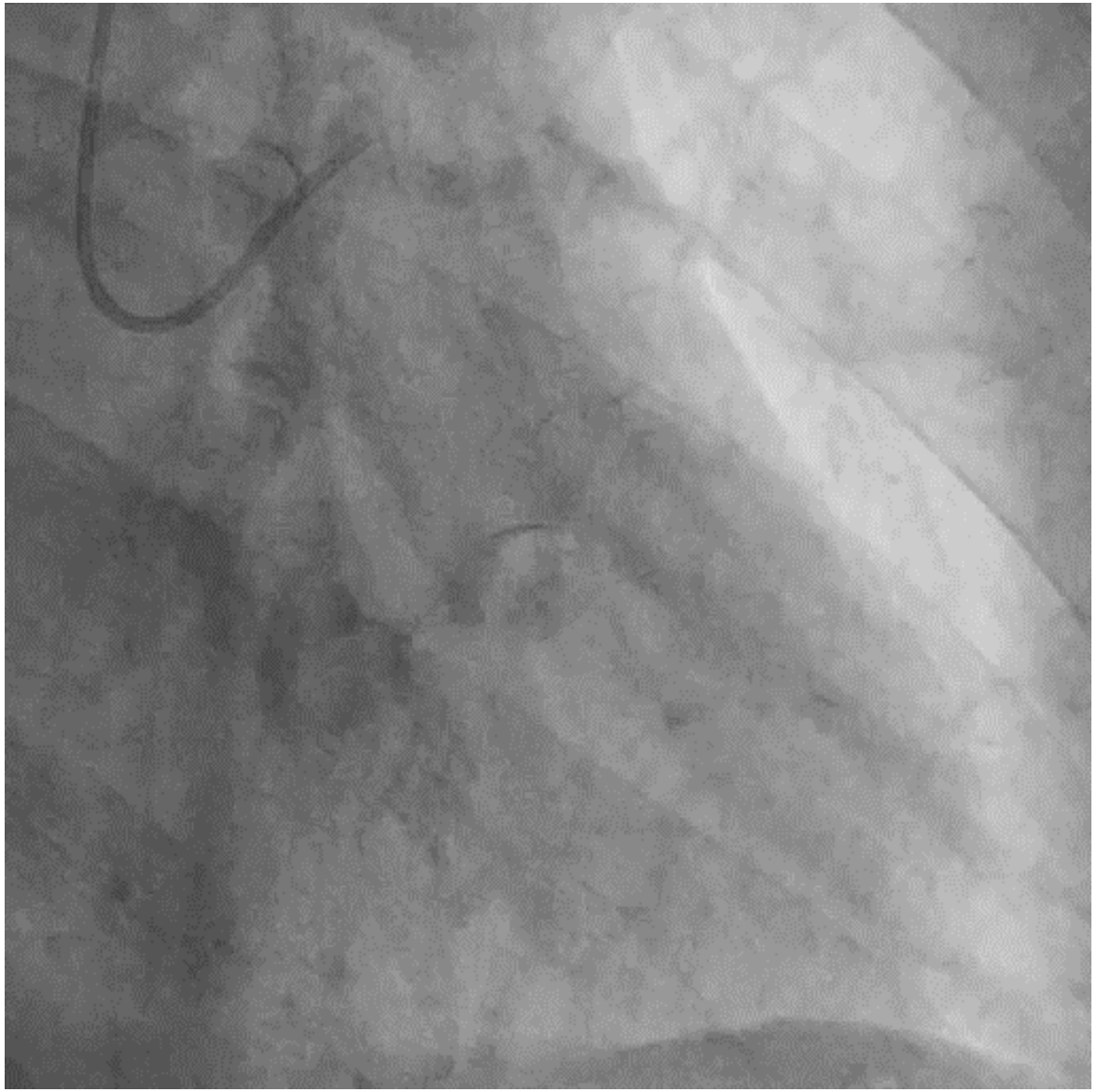


Figure 13.53. coronary artery in the caudal right anterior oblique projection. The left anterior descending artery is short and divides into two parallel arteries: one running over the interventricular sulcus supplying the interventricular septum. The other runs in the anterior wall of the left ventricle and originates the diagonal arteries. It is called the dual left anterior descending artery.



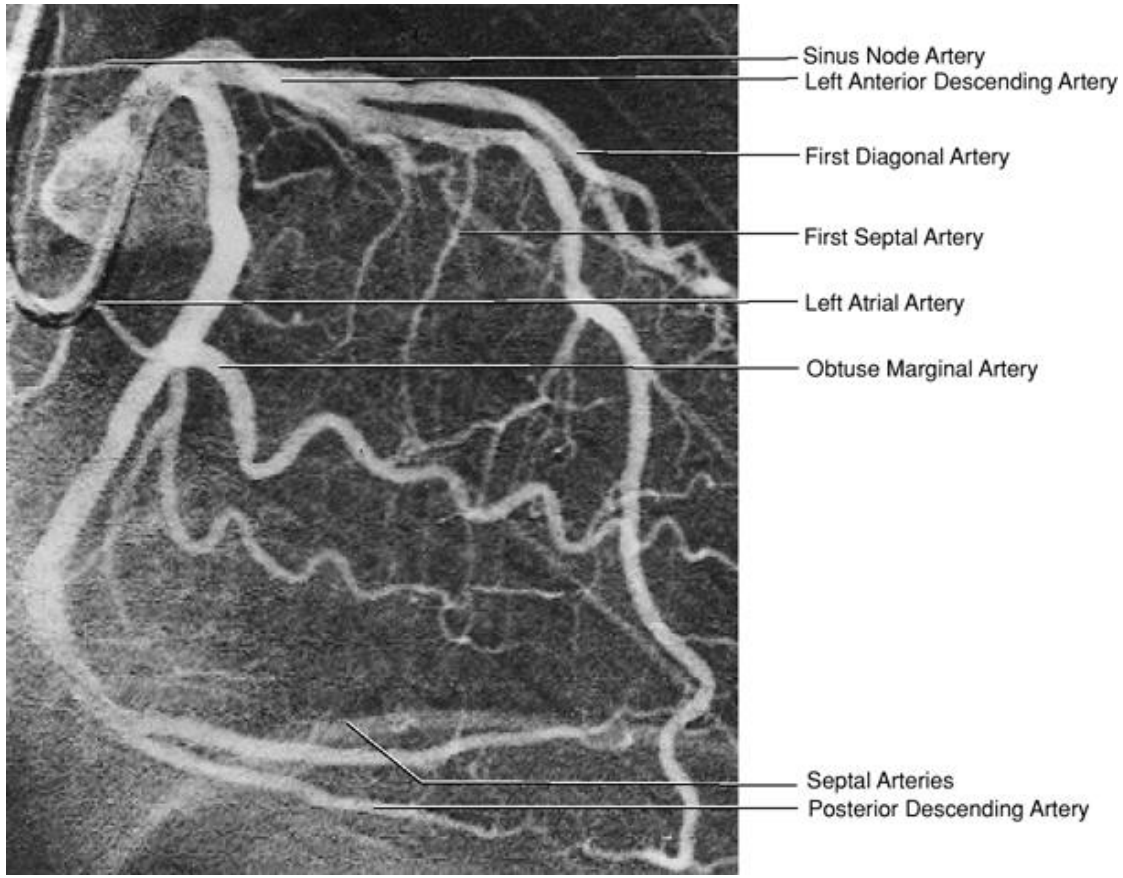
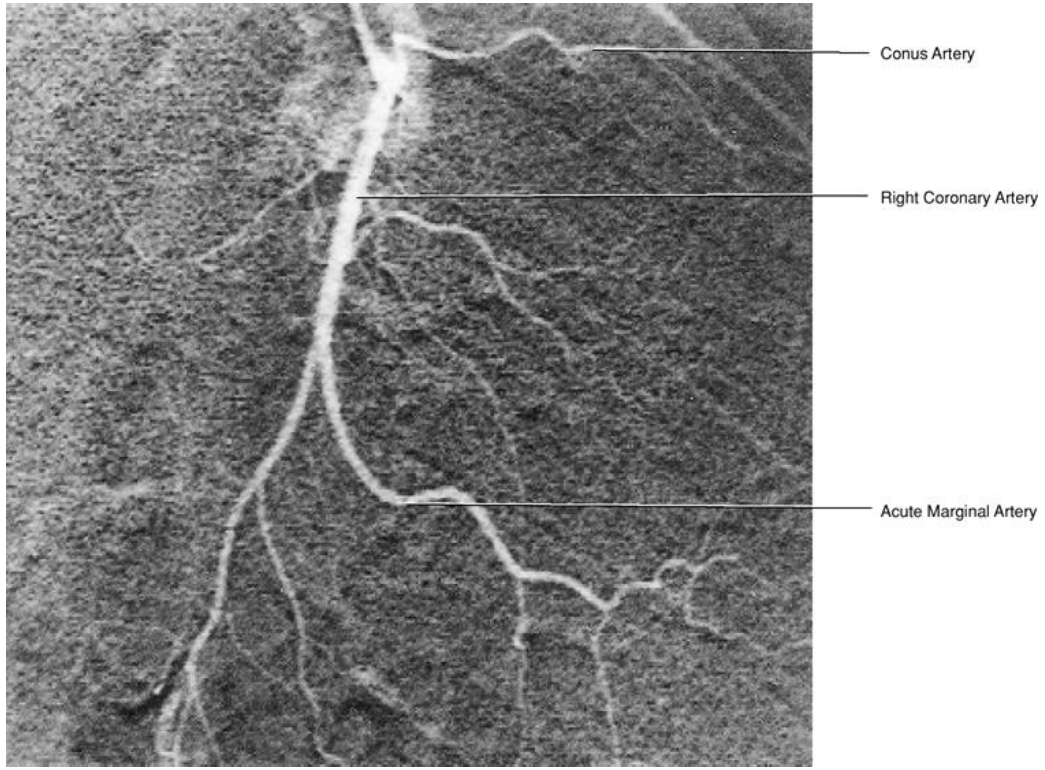


Figure 13.54. Dominant left coronary artery. The posterior descending artery arises distally from the circumflex artery. The sinus node artery is originated from the proximal circumflex artery. This is an angiogram in the cranial right anterior oblique projection.



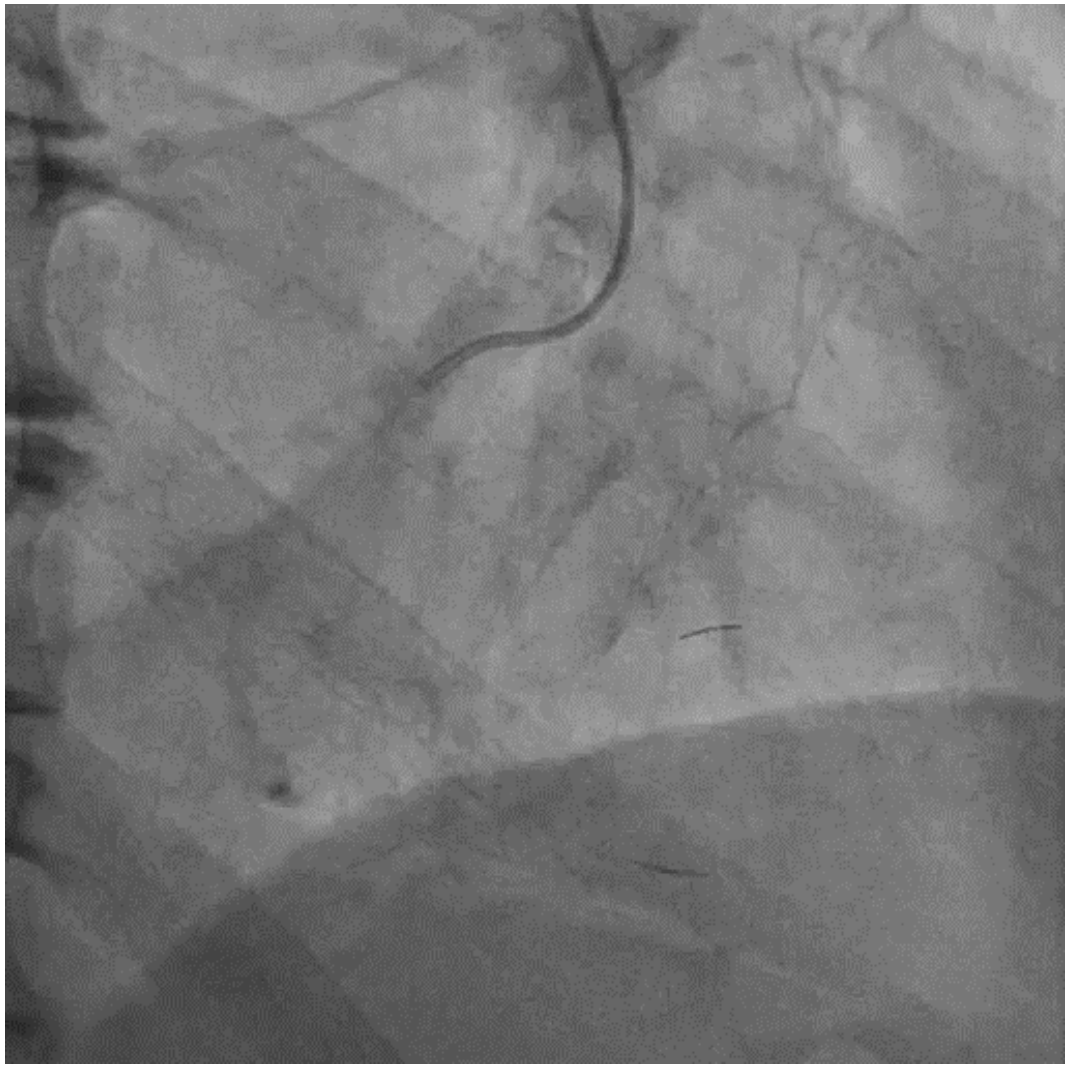


Figure 13.56. Angiogram showing a nondominant right coronary artery in the right anterior oblique projection.

Cardiacangiographic CT

The coronary arteries run in grooves on the surface of the heart surrounded by epicardial fat. This allows CT imaging to use its strength of depicting objects of different density to great advantage.

When intravenous contrast material is given, the coronary arteries surrounded by fat clearly stand out from the remainder of the heart. 3D volume images along with maximum intensity projection images are used to evaluate the coronary arteries.

This allows for visualization of the left main coronary artery, right coronary artery, left anterior descending coronary artery, and the left circumflex coronary artery.

In addition, branches such as diagonals, obtuse marginals, and the posterior descending coronary artery can be seen down to a diameter of 1 mm.

Although many different projections are used to visualize the coronary arteries in clinical practice, the fact that the coronary arteries lie on the surface of the heart makes 3D volume reconstruction the most useful way to study the anatomy.

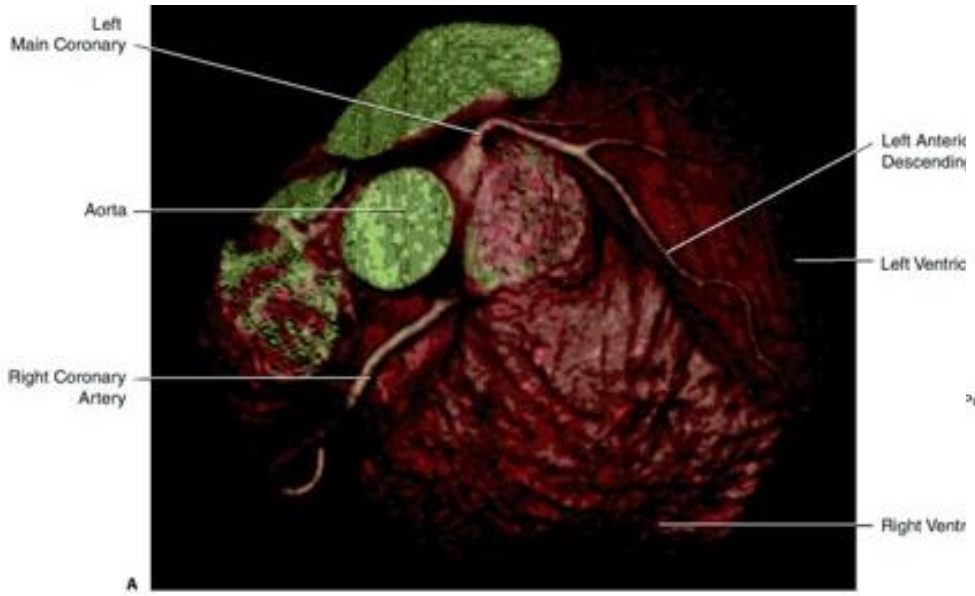
The origin of the coronary arteries can be well visualized on a cranial view with the more superior structures removed.

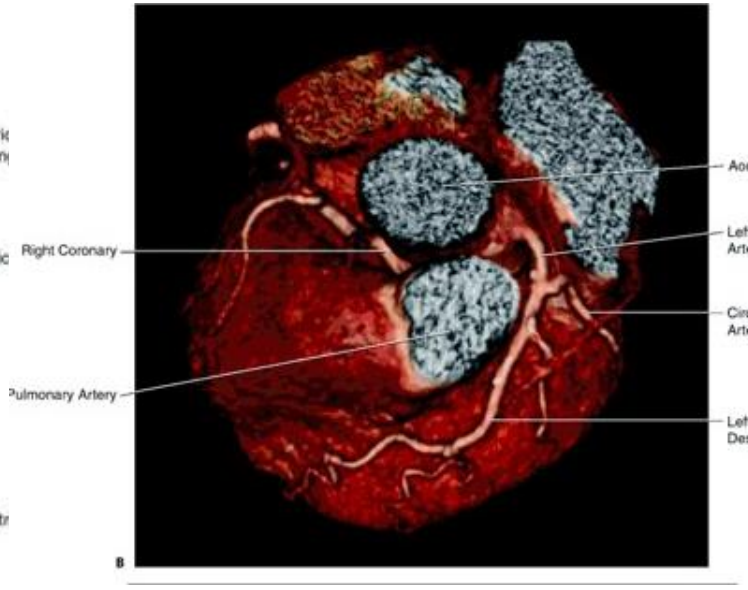
In this projection both the right and left coronary origins are seen clearly and any anomalies can easily be excluded.

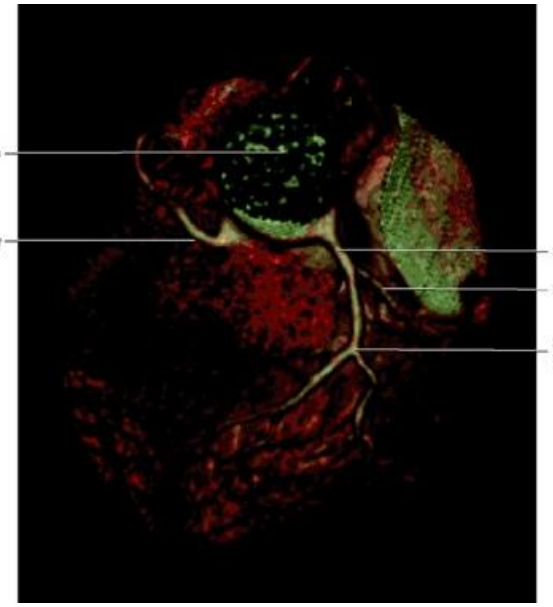
Rotating the image to a cranial left anterior oblique defines the left main coronary artery and its bifurcation into the left anterior descending and left circumflex coronary arteries.

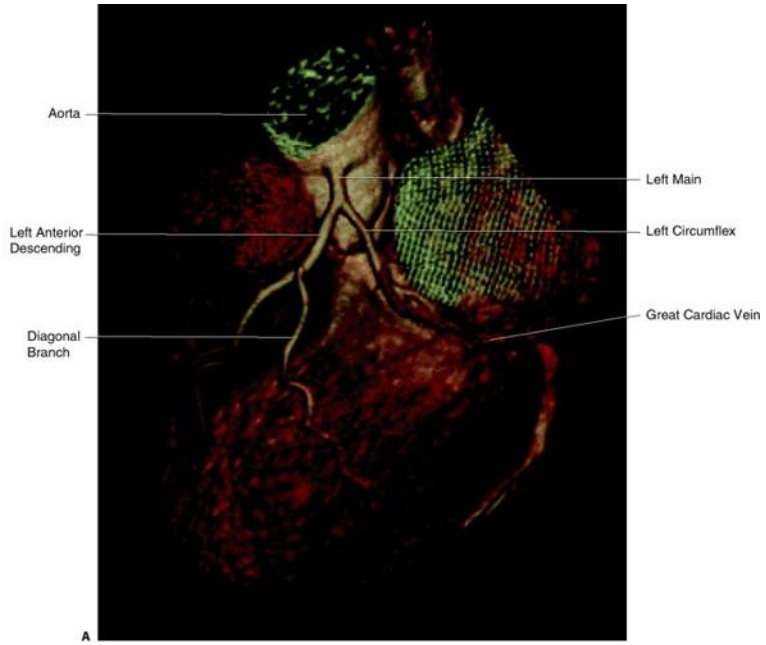
The LAD runs in the anterior interventricular groove with its diagonal branches serving the anterior wall of the left ventricle.

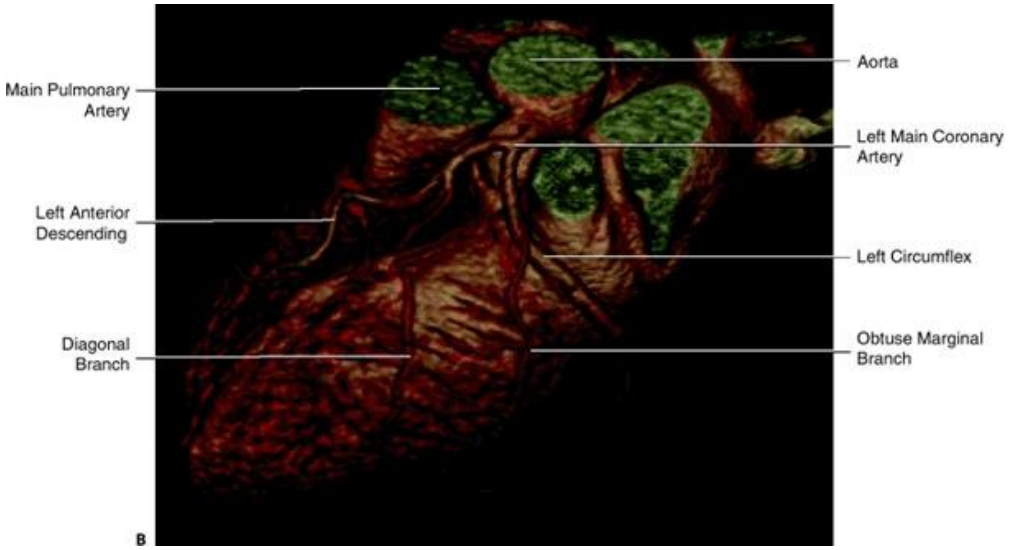
The circumflex coronary artery runs in the atrioventricular groove with obtuse marginal branches serving the lateral wall of the left ventricle.





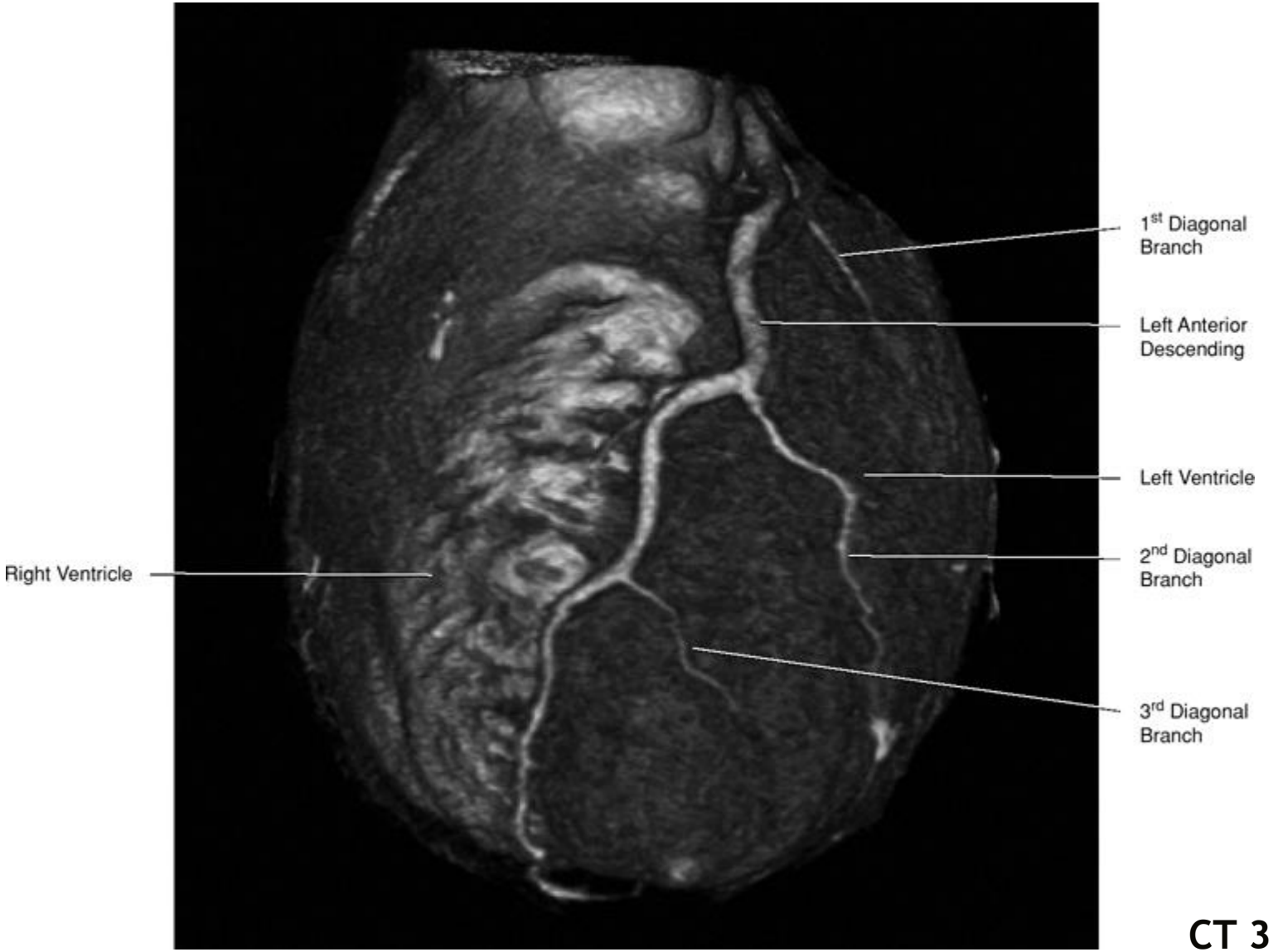




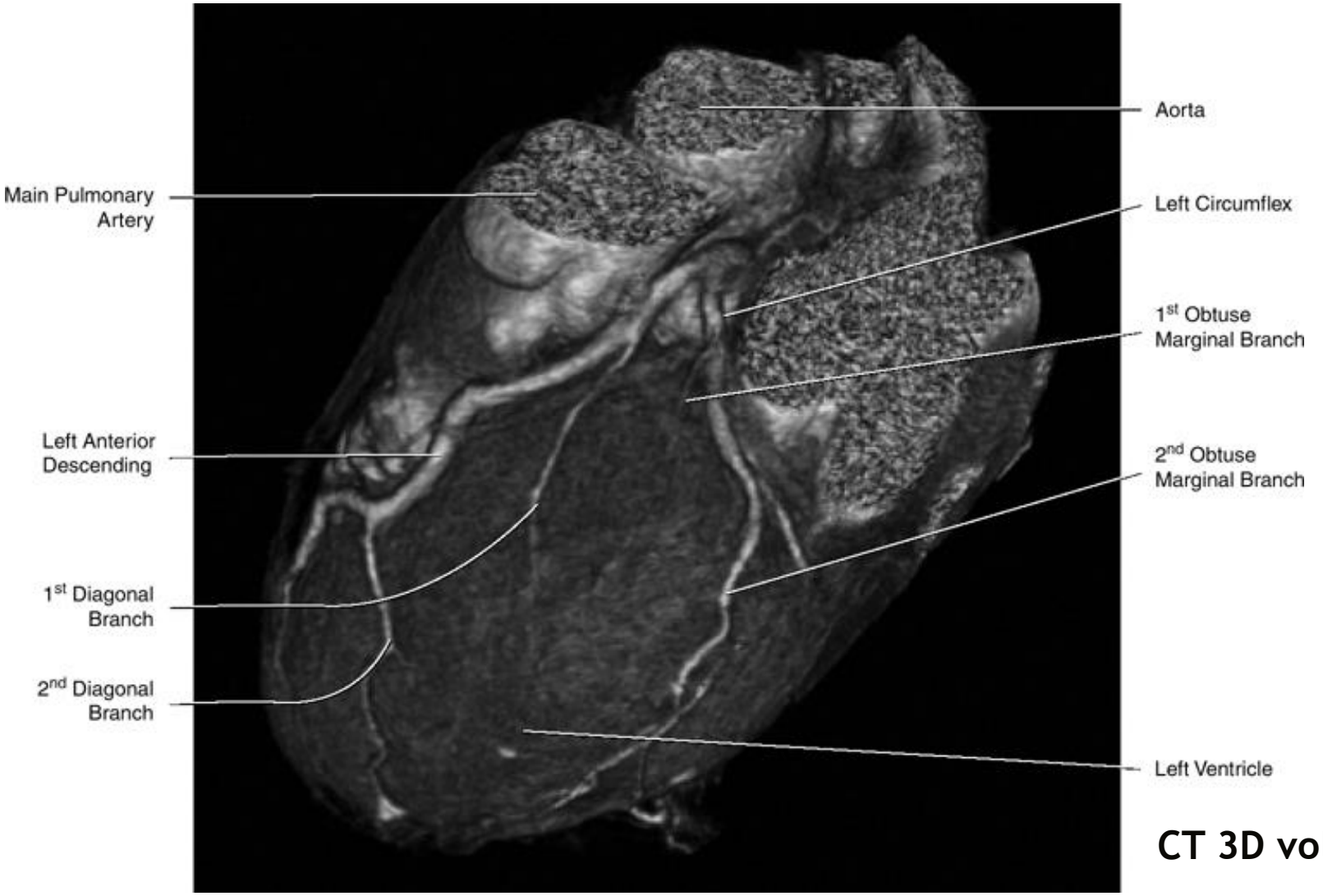


CT 3D volume image.

A–C, Three examples of normal origins of the right and left coronary arteries.



CT 3D volume image.
Left anterior descending coronary artery in anterior interventricular groove with multiple diagonal branches.

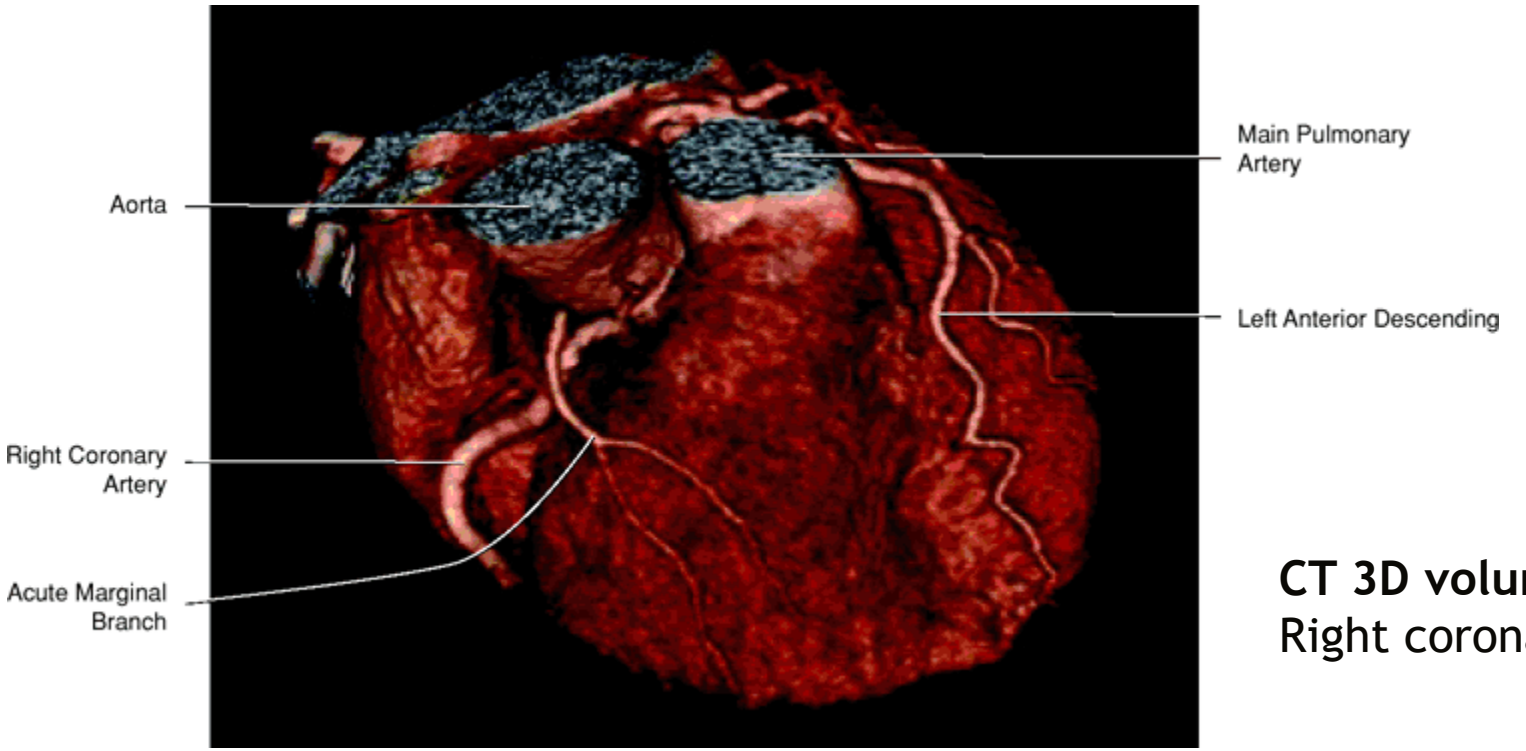


CT 3D volume image.

Left anterior descending coronary artery with diagonal branches and left circumflex coronary artery with obtuse marginal branch.

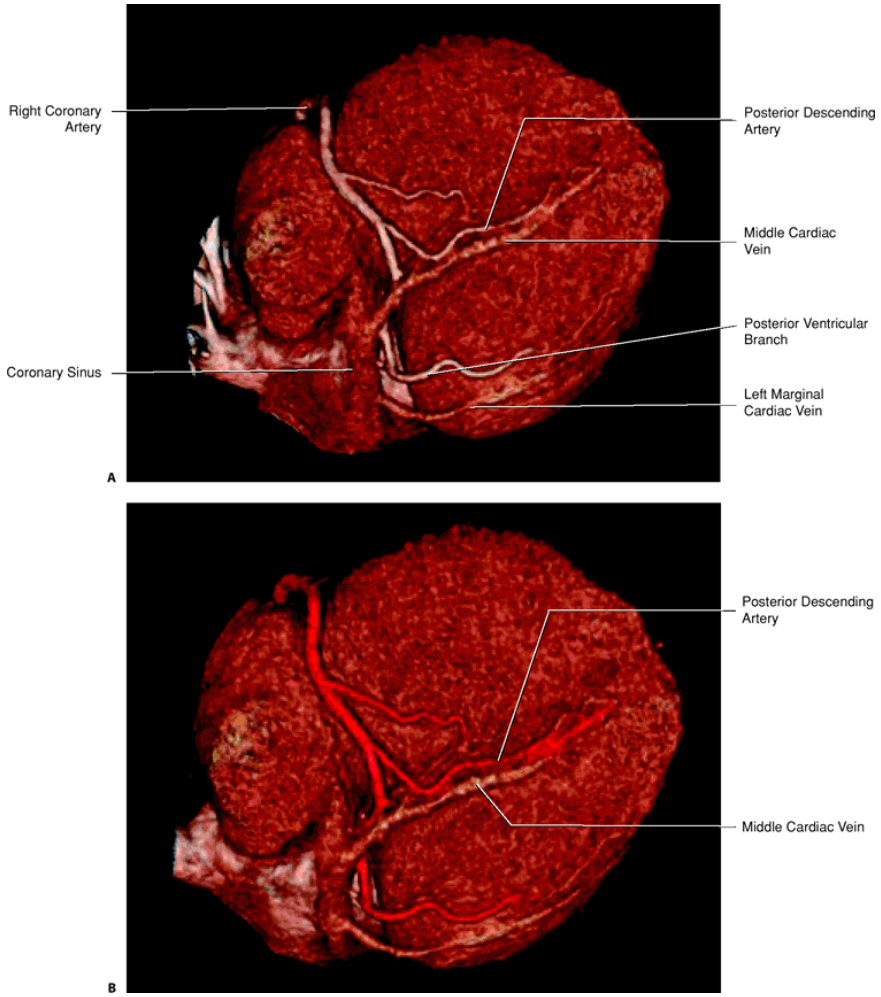
The right coronary artery undergoes rapid complex motion during the cycle of the beating heart. Until recently, this prevented imaging of this vessel because of excessive motion or blurring artifact. Modern scanners are now quick enough to “stop” the motion of the right coronary artery. Small branches less than 1 mm in diameter are difficult to visualize, but larger branches such as the acute marginal artery can be well visualized.

Computer workstations allow these vessels to be displayed in a wide variety of formats, which can be used depending on clinical necessity.

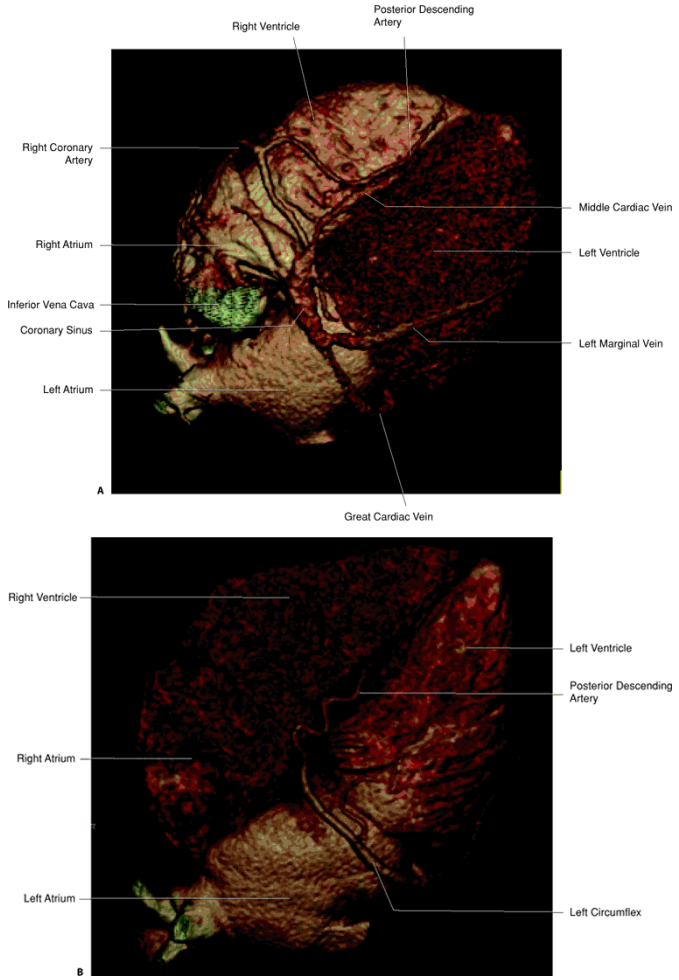


CT 3D volume image.
Right coronary artery with acute marginal branch.

After removing the diaphragm, the inferior surface of the heart can be evaluated. About 80% of people have a so-called "right dominant" system, in which the right coronary artery provides flow to the posterior descending coronary artery. The other 20% have either a left dominant or co-dominant system.



CT 3D volume image with two methods of display. A, Inferior surface of heart with distal right coronary artery giving rise to posterior descending artery. **B,** CT image with highlighted distal right coronary circulation. Note distinction from venous drainage into coronary sinus.



CT 3D volume image inferior surface of heart demonstrating right versus left dominance.
A, Right dominant with right coronary artery supplying flow to the posterior descending coronary artery (PDA). Note slight variant anatomy with early take-off of PDA. **B,** Left dominant with circumflex supplying PDA. Note veins and coronary sinus removed to better demonstrate distal left circumflex artery.