Introduction

- Anatomy of coronary arteries has been described for at least 300 years ago.
- Most radiographic and clinical descriptions have been based on cine angiograms.
- CT angio now provides detailed anatomic information of coronaries, using a firm understanding of gross anatomy.
Old...
Old vs New
Heart Anatomy

Figure 18.1

Midsternal line
2nd rib
Sternum
Diaphragm
Point of maximal intensity (PMI)

Right lung
Heart

Superior vena cava
Left lung
Aorta
Parietal pleura (cut)
Pulmonary trunk
Parietal pericardium (cut)
Apex of heart
Diaphragm
Coronary Circulation: Arterial Supply

- Superior vena cava
- Anastomosis (junction of vessels)
- Right coronary artery
- Right atrium
- Marginal artery
- Posterior interventricular artery
- Anterior interventricular artery
- Aorta
- Pulmonary trunk
- Left coronary artery
- Left atrium
- Circumflex artery
- Right ventricle
- Left ventricle
Normal coronary anatomy viewed from the sternocostal (anterior) surface.
Right-dominant circulation viewed from the diaphragmatic surface of the heart. Note how the right coronary artery travels in the posterior interventricular sulcus, giving rise to the posterior descending artery. 

[LM = left main artery; LAD = left anterior descending artery; Cx = circumflex; RCA = right coronary artery; S = septal; D = diagonal; OM = obtuse marginal; RM = right marginal; RPDA = right posterior descending artery; RPL = right posterolateral; RI = ramus intermediate.]
The Dominance Concept

- Description of artery that gives rise to PDA, PLA and AV nodal arteries (supplying the inferior aspect of interventricular septum, inferior of left ventricle and AV node)
- Co-dominant
  - 85% of general population is right dominant
  - 8% are left dominant
  - 7% are co-dominant
Right-dominant circulation.
Left-dominant circulation
Left-dominant circulation viewed from the diaphragmatic surface of the heart. Note how the circumflex gives rise to the posterior descending artery.
Coronary Artery Anatomy: Origins
Diagram showing the sinotubular junction (top dashed line) where the tubular aorta meets the bulbar sinuses of Valsalva.
Diagram showing the aortic root dissected open. The bulbous sinuses merge with the aortic valve cusps to form the sinuses of Valsalva. The coronary ostia are located below the sinotubular ridge, within the sinus of Valsalva, centrally located between the commissural attachments of the aortic cusps.
Right Coronary Artery (RCA)

- Origins from ostium, lies deep in the epicardial fat between pulmonary conus and RA (behind RA appendage)

- Branches take off at right angles

- Branches:
  - Conus artery
  - RA branches
  - RV branch
  - Interventricular septal branches
  - AV nodal branch
right coronary artery with the SA node artery in a right anterior oblique view with corresponding angiogram.
RCA

- For lesion classification, may be divided into proximal, middle and distal

- Conus artery (infundibular A, adipose A, third coronary A, artery of Viussens) has separate origin than RCA in up to 50% cases. My become vascular anastomosis bridge to LMS or pLAD (circle of Vieussens)

- Atrial branch travels down the atrioventricular sulcus, penetrates into interartrial septum, circles the SVC (branches called ramus crista terminalis) and terminates in SA node (60%)

- RV branch – anterior, marginal and posterior RV
Diagram illustrating the proximal, mid, and distal segments of the right coronary artery. [Prox. = proximal; Dist. = distal; PD = posterior descending.]
A 64-slice echocardiographic-gated cardiac CT scan showing a normal right coronary artery
right coronary artery with the SA node artery in a right anterior oblique view with corresponding angiogram.
RCA

- Posterior descending artery (PDA) arises from distal RCA and travels to the apex, giving short interventricular branches (<15 mm)
- Superior septal artery in 12-20% supplying the AV node and septum
- AV node artery in up to 90% from RCA
- Posterolateral artery (PLA) supplies the inferior wall of left ventricle
Heart Physiology: Sequence of Excitation

1. Sinoatrial (SA) node (pacemaker)
2. Atrioventricular (AV) node
3. Atrioventricular (AV) bundle (Bundle of His)
4. Bundle branches
5. Purkinje fibers
Diagram illustrating the right coronary artery [RCA] and the course of the sinoatrial [SA] node artery.

(A) Right coronary artery with the SA nodal artery in the left anterior oblique view with a corresponding angiogram
Left Coronary Artery

- Left Main artery (LMS)
- Left Anterior descending (LAD)
- Left Circumflex Artery (LCx)
- Intermediate Artery (Ramus Intermediate, Median Artery, Left Diagonal Artery, Straight LV Artery)
Left Main Artery

- Arises from left sinus of Valsalva, course laterally between base of pulmonary trunk and LA
- Length usually 2-12mm (even 30mm) with diameter from 5-10mm
Diagram showing the left coronary artery. The left main courses around the pulmonary artery to bifurcate into the left anterior descending and left circumflex arteries.
FIGURE 7. Diagram showing the left coronary artery. The left main courses around the pulmonary artery to bifurcate into the left anterior descending and left circumflex arteries.
Normal cardiac CT depiction of the coronary arteries. Volume-rendered 3-dimensional (3D) reconstructed image of the right and left coronary arteries.
Left Anterior Descending

- Passes left of pulmonary trunk and on the interventricular sulcus towards apex.
- 90 degree turn usually after 2nd diagonal – point for surgical bypass
- Occasionally bifurcates into 2 parallel vessels towards apex
- Often covered by superficial muscle fibers “myocardial bridging”
Diagram showing the left coronary artery. The left main courses around the pulmonary artery to bifurcate into the left anterior descending and left circumflex arteries.
LAD

- Often divided to proximal (till first major septal branch), mid (till 90 degree angle or 2nd diagonal) and distal
- Gives diagonal branches (2 to 9)
- May have RV branch
- Septal branches penetrates 2/3 into anterior septum (40-80 mm long). “anchors” LAD and limits motion/buckling during systole
Left Circumflex (LCx) Artery

- Arises from LMS at right angle
- Runs in the atrioventricular sulcus till crux, mirrors the RCA
- Proximal (till OM1), mid (till OM2), distal
- 40% subjects has left atrial branch supplying the SA node
- Kugel’s artery – early anterior atrial branch anastomotic network between RCA and LCx
- Obtuse Marginal (OM) – supplies left ventricle anteriorly, marginally or posteriorly – usually 1-3 branches
Diagram showing the left coronary artery. The left main courses around the pulmonary artery to bifurcate into the left anterior descending and left circumflex arteries.
Anatomic Variations

Found in 1% of patients undergoing angiography and 0.3% of autopsy.

…..especially with ECG-gated MSCT getting more popular screening tool for coronary investigation! – reported up to 51%

Table 1. Coronary anomalies

A. Anomalies without shunt
   1. Abnormal number of coronary arteries
      a. One ostium
      b. Three ostia
      c. Four ostia
   2. Anomalous origin of coronary arteries
      a. Outside sinus of Valsalva
      b. Independent origin from corresponding sinus
      c. Origin from other sinus
      d. Origin from other artery
   3. Myocardial bridge
   4. Segmental hypoplasia/stenosis/arteria

B. Anomalies with shunt
   1. Fistulas
   2. Anomalous coronary origin from the pulmonary artery

C. Aneurysms
   1. Congenital
   2. Acquired
Anomalies without shunt

- **Coronary numbers anomaly**
  - Single coronary artery in 0.024%, benign but associated with congenital heart disease – TGA, TOF, Coronary artery fistula
  - Often mistaken for 2 separate ostia in the same sinus of valsalva
  - Separate conus artery ostium from RCA, separate LCX and LAD (no left main) etc

- **Coronary ostia anomaly**
  - Coronary artery originates from the tubular portion of aorta – get MSCT to outline the anatomy before catheterization!
  - Anomalous origin of coronary artery (AOCA) from opposite sinus of valsalva
Multislice cardiac CT with 3-dimensional (3D) reconstruction depicting separate ostia of the left anterior descending (LA) and circumflex (Cx) arteries: (A) a coronal oblique maximum-intensity projection image and (B) a 3D rendered reconstruction. The straight arrows indicate the LAD and the curved arrows indicate the Cx. [A = aorta; PA = pulmonary artery.]
Three-dimensional reconstructed depiction of a high anterior takeoff of the right coronary artery from 64-slice cardiac CT: (A) coronal and (B) sagittal views. [Ao = aorta; MPA = main pulmonary artery; RA = right atrium; RCA = right coronary artery; RVOT = right ventricular outflow tract; RV = right ventricle; LV = left ventricle; Pulm Valve = pulmonary valve; LCX = left circumflex artery.]
Corresponding cine coronary angiogram showing the right coronary artery.
Anomalous Origin of Coronary Artery (AOCA)

- Associated with myocardial ischemia, ventricular arrhythmia and sudden death
- Rare
- ? Sudden death in athletes – (due to slit-like lumen, acute angle or compression)
- Anomalous origin of RCA from left sinus (0.1%)
- Anomalous LMS from right sinus with interarterial course (0.03-0.05%) – frequently associated with sudden death
- Anomalous origin of LCx takes retroaortic course – may be injured during MV surgery
- Treatment – surgery – bypass graft, patch enlargement, reimplantation, unroofing
Anomalous left coronary artery from the right coronary cusp. The left coronary emerges from the right coronary cusp and travels in the interarterial sulcus between the aorta [Ao] and pulmonary artery [PA]. [LA = left main artery, RA = right coronary artery.]
Anomalous right coronary artery from the left coronary cusp. (A) Multislice cardiac CT with 3-dimensional reconstruction showing the right coronary artery from the left coronary cusp. The right coronary artery travels in the interatrial sulcus between the aorta [A] and the pulmonary artery [PA]. The curved arrow identifies the normal left main. The arrowhead indicates the acute angle at which the right coronary extends from the left cusp and its slit-like ostium. The arrow shows the normal-caliber right coronary artery.
An anomalous left circumflex artery shown on a 16-channel multidetector row cardiac CT. Arrows illustrate the circumflex artery as it originates from the right coronary cusp, travels retroaortically, and assumes the normal position and distribution.
Myocardial Bridging

- Coronary artery esp LAD covered by superficial myocardial fibers at right angle to the artery
- Usually short portion
- Visualized during systole
- May cause angina, MI
- Medically treated
Multislice cardiac CT scans showing myocardial bridging. Note how the course of the left anterior descending artery becomes interrupted as it becomes intramyocardial and then reemerges distally.
Coronary Artery Fistula

- Connection between coronary artery to artery, vein or cardiac chamber
- Seen in 0.1-0.2%, more common to the venous structure
- Flow to RV (45%), RA (25%), PA (15%) rarely to SVC and CS
- Often coronary artery is tortuous and dilated with rapid draining flow to the draining chamber, while native artery flow is poor due to steal of flow, causing ischemia
- May be treated surgically or trans catheter.
Multislice cardiac CT showing a coronary artery fistula. The arrows show the dilated left circumflex coronary artery.
Anomalous Origin of Coronary Artery from Pulmonary Artery (ALCAPA)

- Usually affects left coronary artery but may involve both
- Bland-White-Garland syndrome most common, LCA from PA and RCA from aorta
- Rare congenital anomaly – 1:300,000.
- 90% die in the first year
Bland-White-Garland syndrome. (A) The left coronary artery is shown originating from the pulmonary artery (PA; straight arrow) and multiple collateral vessels in the interventricular septum (arrowheads). (B) This image shows the anomalous origin of the left coronary artery (straight arrow) and a dilated right coronary artery (curved arrow). [A = aorta]
Coronary Artery Aneurysm

- Not common
- Presents with large artery, slow flow and late filling of distal bed
Coronary Circulation: Venous Supply

- Superior vena cava
- Anterior cardiac veins
- Great cardiac vein
- Coronary sinus
- Small cardiac vein
- Middle cardiac vein
Normal coronary anatomy and anatomic variations

David M. Fiss, MD

With the evolution of multislice, multidetector cardiac CT, noninvasive imaging of small moving structures, such as coronary arteries, has become possible. Until now, imaging of the coronary arterial tree has been limited to angiograms. With cardiac CT, which provides detailed anatomic information, a firm understanding of gross anatomy with an appreciation of normal origin, branching, myocardial distribution, and adjacent structures is essential for accurate image interpretation. Furthermore, without a detailed appreciation of normal anatomy, coronary artery anomalies may go undiagnosed. This article will review normal coronary arterial anatomy from both anatomic and clinical standpoints, anatomic anomalies of the coronary arteries, and applications of cardiac CT in patient evaluation.

The anatomy of the coronary vessels has been described in detail for at least 3 centuries. Strict anatomic descriptions of the coronary vessels are available from standard textbooks of gross anatomy. However, most of the textbook descriptions are based on views and perspectives obtained from tissue, emphasizing landmarks that are visible on the gross specimen. These landmarks are not easily recognizable on traditional cine radiographic images.

Until recently, most radiographic and clinical descriptions of the coronary arteries have been based on cine coronary arteriograms. When studying a cine arteriogram, however, a physician uses an entirely different set of reference points and is less inclined to emphasize landmarks that are seen only on the gross specimen. Because these anatomic landmarks are not easily recognized with traditional arteriography, clinicians have adopted slightly different nomenclature to describe normal coronary anatomy, concentrating more on vessels with clinical rather than anatomic significance.

Cardiac computed tomography (CT) provides detailed anatomic information, but its use requires a firm understanding of gross coronary anatomy. Furthermore, detailed appreciation of the "normal" origin, course, branching, adjacent structures, and myocardial distribution of these vessels is vital so that variations of the "normal" anatomy can be more easily recognized and applied to clinical practice.

This article will review normal coronary arterial anatomy from both anatomic and clinical standpoints, anatomic anomalies of the coronary arteries, and applications of cardiac CT in patient evaluation.

Normal coronary artery anatomy

There are many variations of "normal" that are not considered "anomalous." Additionally, an understanding of which arterial branch perfuses which myocardial segment is germane to the physician when making individual patient care decisions. As a result, the concept of dominance has been adopted into the clinical vernacular to describe which artery gives rise to the posterior descending artery (PDA), the posterolateral artery (PLA), and the atrioventricular (AV) nodal artery, which, in turn, supply the inferior aspect of the interventricular septum, the inferior aspect of the left ventricle, and the AV node, respectively. If these arteries originate from the right coronary artery (RCA), the circulation can be classified as "right-dominant" (Figure 1). Alternatively, if supplied by the left circumflex artery (LCA), the circulation can be classified as "left-dominant" (Figure 2). In such patients, the right coronary artery is quite small and supplies only the right atrium and right ventricle. In the case of "co-dominant" circulation, the right coronary artery supplies the PDA and terminates. The left circumflex artery supplies the PLA with an occasional parallel posterior descending branch that supplies the inferior interventricular septum. Approximately 85% of the general population is right-dominant, 8% are left-dominant, and 7% are co-dominant.

In the vast majority of people, there are two main coronary arteries, right and left, which arise from separate ostia in the aorta. The bulbar aortic sinuses and the proximal ascending aorta comprise the aortic root. A slight circumferential thickening, known as the sinotubular ridge (sinotubular junction), marks the separation of these two
Thank You.