

Coronary Artery Anomalies from Birth to Adulthood; the Role of CT Coronary Angiography in Sudden Cardiac Death Screening

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Learning Objectives

- To discuss the technique of CT coronary angiography.
- To describe the classic cardiac anatomy, common cardiac anomalies and the proposed mechanism of injury that leads to sudden cardiac death.
- To provide an easily accessible tool which aids radiologists when reporting coronary anatomy anomalies.



CT Cardiac Angiography

Non invasive CT angiogram which provides submillimetre resolution to allow capture whole heart <1second: 3D volume of data in one heart beat

Concept: Time gated acquisition to cardiac cycle to allow motion free image acquisition

- Low coronary motion during mid-late diastole

ECG gated

- Retrospective
- Prospective

HR <65bpm

Beta blockers and GTN pre CT

64 detector CT minimum

Weight based Contrast dose



Benefits of CT coronary angiography for coronary anatomy

- Well tolerated by patients*
- Low radiation dose*
- Conventional angiography can incompletely delineate the complex nature of the anomalous coronary anatomy
 - 2D nature of angiography can fail to demonstrate the relationship to surrounding structures and identify the course of aberrant artery.
 - Aberrant artery may not be appreciated if not selectively engaged
- Echocardiography can delineate anomalous anatomy if specifically investigated
 - Operator dependant
- MRI limited by spatial resolution
- 3D coronary MRA sensitive to motion, gating artefact

*Important in screening population

Basics:

Coronary Artery Anatomy

Normal

Anatomy seen in > 99% of the population

Variant

Unusual anatomy seen in > 1%

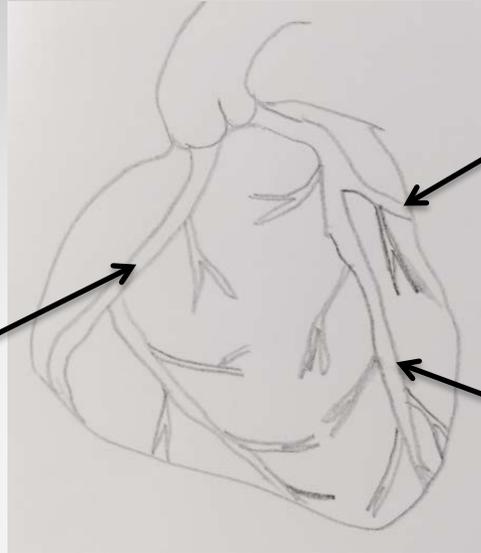
Anomaly

Unusual and uncommon anatomy in < 1% of the population

Significance of Anomalies: Cause of sudden adult cardiac death in up to 19% young adults.

Normal Anatomy

Right coronary artery (RCA) perfuses the right ventricular free wall and, if dominant, inferior interventricular septum and inferior LV wall.



Left circumflex artery (LCx) perfuses the lateral wall of the left ventricle and anterior LV wall

Left anterior descending (LAD) perfuses the anterior interventricular septum and anterior LV wall

| Features | Range |
|----------------------|-------------------------------|
| No of ostia | 2-4 |
| Location | Right and left anterior sinus |
| Orientation | 45-90° |
| Proximal common stem | Left |
| Proximal course | Direct, subepicardial |
| Termination | Capillary bed |

Coronary Anomalies

Classification:

1. Anomalous origin and course (87%)
 1. Anomalies of intrinsic anatomy
 1. Anomalies of termination (13%)

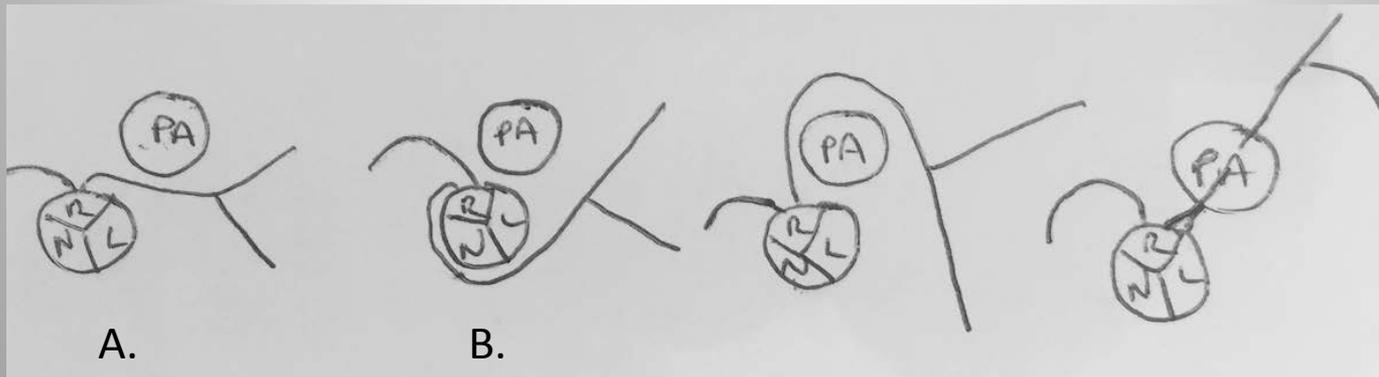
Anomalous origin and course

1. Anomalous origin at improper sinus
 - Common origin
 - RCA from left coronary sinus
 - LAD/LCx from right coronary sinus
 - RCA/LCA arising from non coronary sinus
2. Absent left main
3. Anomalous location of the ostium
 - High take off
4. ALCAPA

Anomalous origin and course:

Anomalous origin at improper sinus

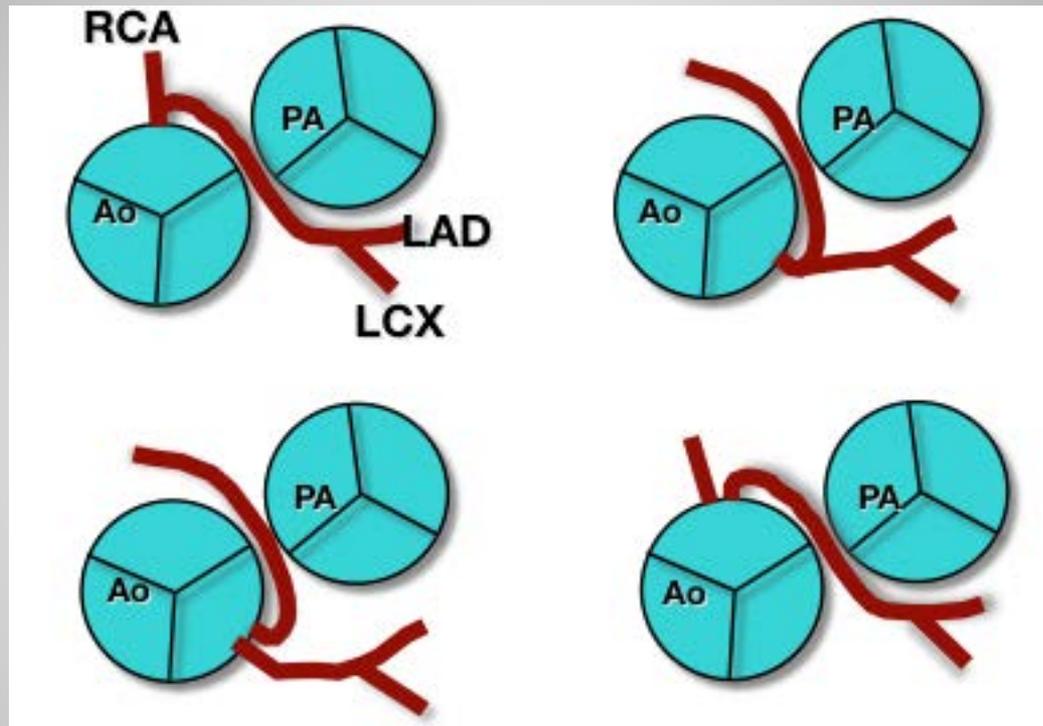
- Single coronary artery arises from right coronary sinus
- LCA arises from right coronary sinus
- LAD arises from right coronary sinus
- LCx arises from right coronary sinus
- RCA arising from left coronary sinus



Pictorial representation of LCA anomalous course

A. Interarterial ; B. Retrocardiac, C. Prepulmonic, D. Subpulmonic

Interarterial Course

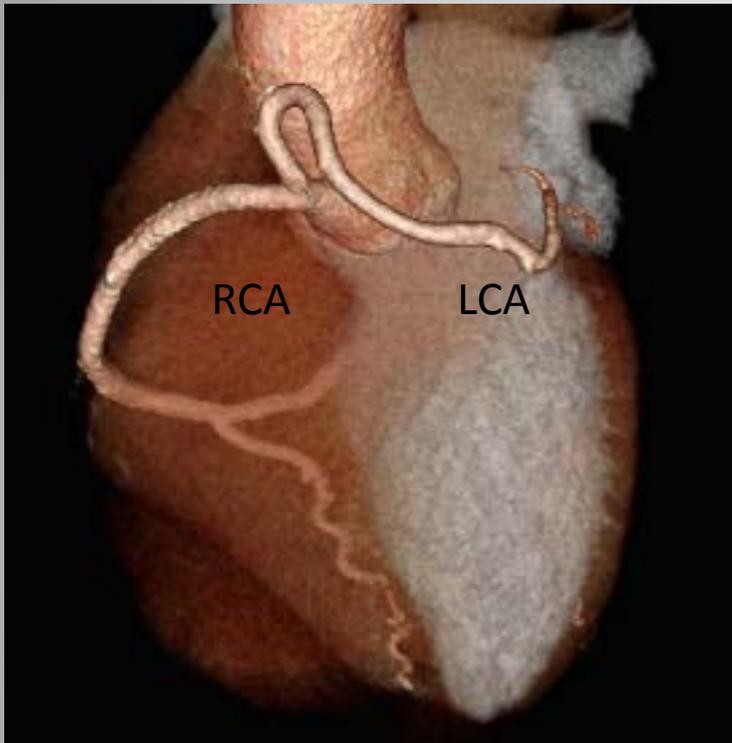


Coronary artery passes between aorta and pulmonary artery to return to normal course. Can occur with a number of anomalous origins patterns

Significance: During exercise aorta dilates which can cause compression of interarterial segment

Anomalies of Origin and Course:

Common Origin



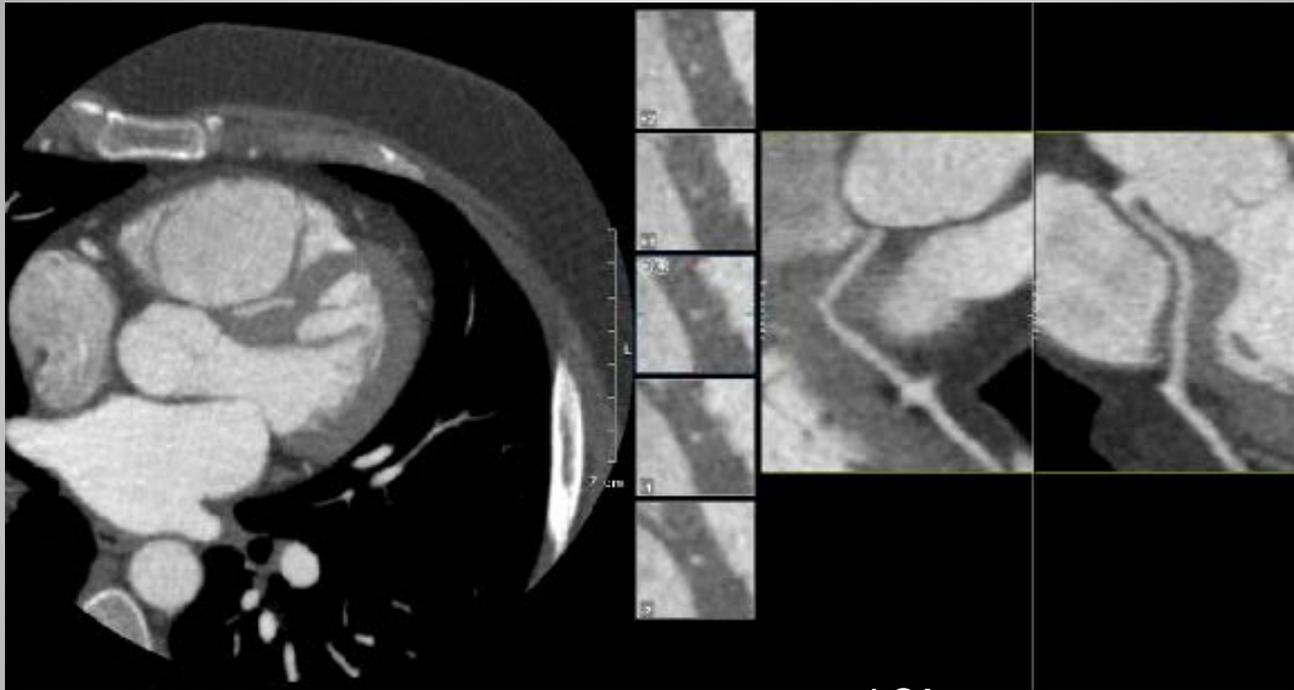
3D reconstructed image from CT coronary angiography in 35 year old asymptomatic female demonstrating **common origin** of left main and right coronary artery from **right coronary cusp** with interarterial course of left coronary artery

Clinical significance:

- Prevalence 0.04%
- Single ostium= Single coronary artery with early branching into LCA and RCA
- Associated with interarterial course
- **Proposed role in sudden cardiac death:** *Episodic ischemia, premature ATH*

Anomalies of Origin and Course:

Aberrant LCA



LCA

LCA arising from Right coronary sinus and coursing interarterially.

- Prevalence 0.5%
- 2 ostium identified
- 75% have interarterial course
- **Proposed role in sudden cardiac death:** *Episodic ischemia, premature ATH*

Anomalies of Origin and Course:

Aberrant LCx



LCx arises from right coronary sinus.

- Prevalence 0.5%
- Typically *retroaortic* course and thus is not usually implicated in sudden adult death.

Anomalies of Origin and Course:

Aberrant RCA

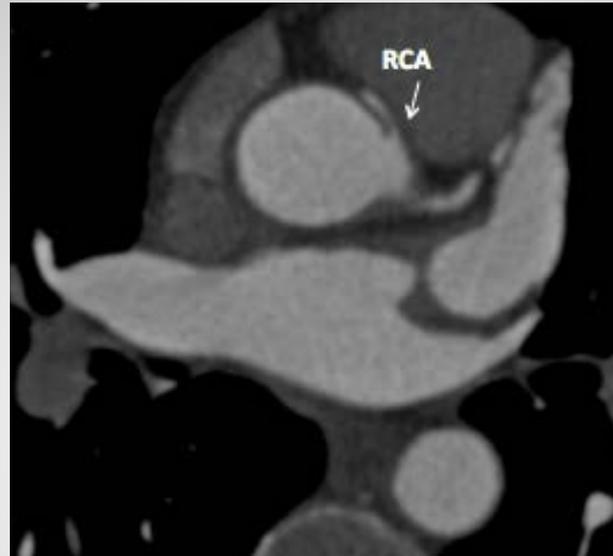


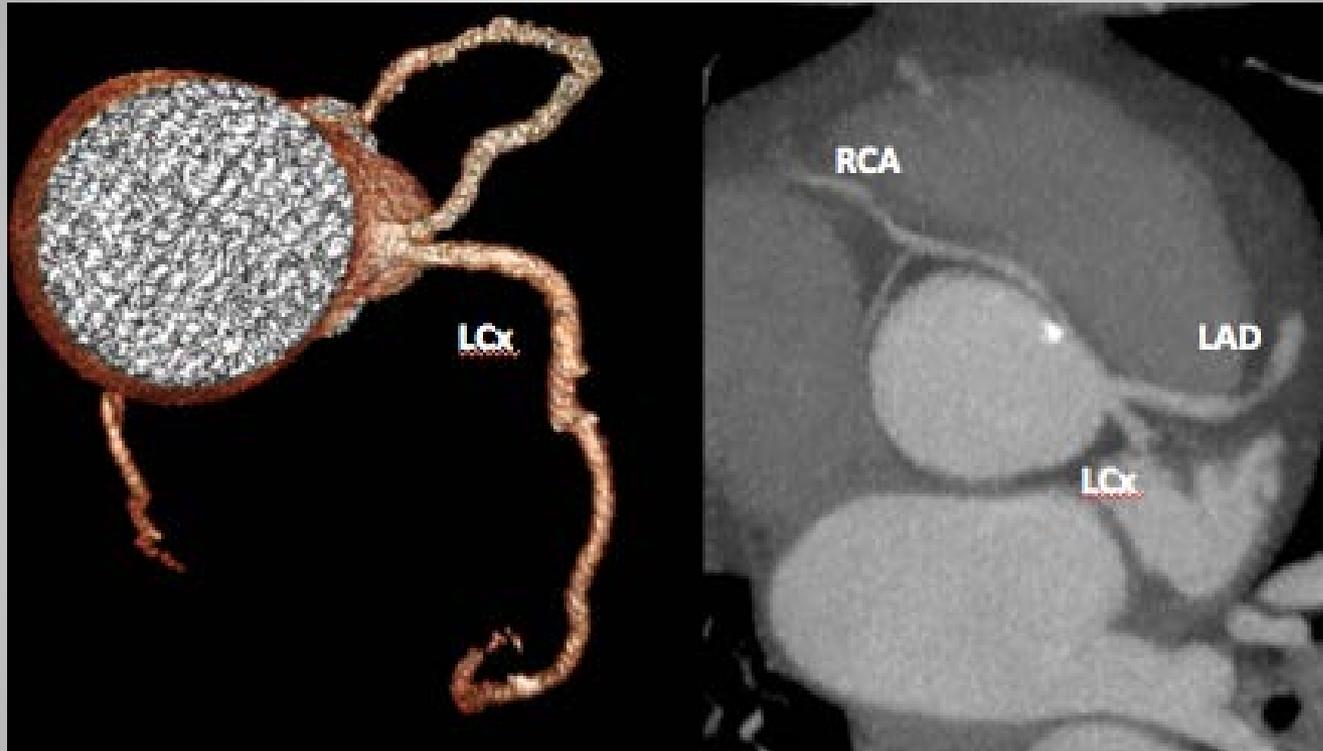
Image from CT coronary angiography in 25 year old male (screening study) demonstrating right coronary artery arising from the left coronary sinus and coursing interarterially.

Clinical significance:

- Prevalence 0.2-0.9%
- Can occur as single vessel or branch
- **Proposed role in sudden cardiac death: *Episodic ischemia***
 - **Up to 70% associated with sudden adult death if interarterial course**

Anomalies of Origin and Course:

Absent Left Main Coronary Artery

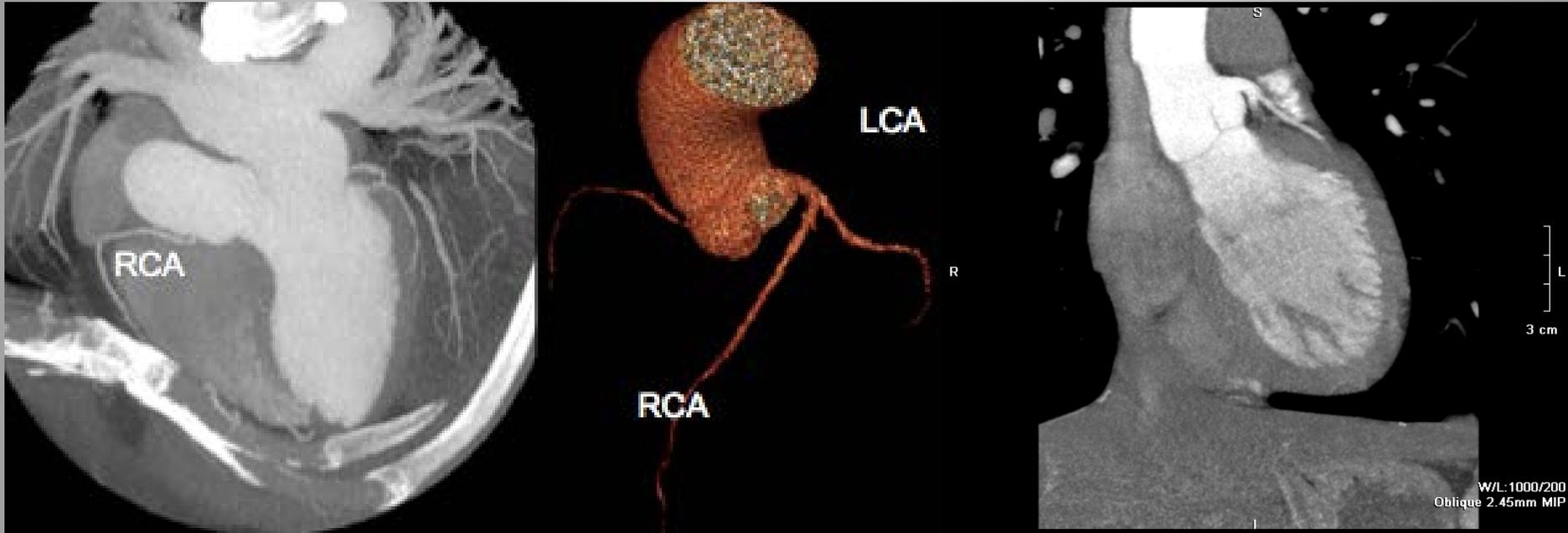


Prevalence: 0.7%

LCx and LAD arise directly from left coronary sinus.

Typically not implicated in sudden adult death.

Anomalies of Origin and Course:
High Take Off



'High take off'

Origin of LCA or RCA is at a point above the junctional zone between the sinus and the tubular part of the ascending aorta. The above images demonstrate high take off of RCA

Typically not implicated in sudden adult death

Anomalies of Origin and Course:

ALCAPA

Anomalous origin of coronary artery from pulmonary artery (ALCAPA)

- Serious congenital anomaly
- 1 in 300000 live births
- Symptomatic in infancy
 - If untreated 90% die in first year of life

Bland-White-Garland Syndrome

- LCA arises from pulmonary artery and RCA arises from aorta
- CTA/Angiography: collateral circulation between RCA and LCA with **steal phenomenon into pulmonary artery.**

Proposed role in sudden cardiac death: Fixed ischemia

Anomalies of Intrinsic Anatomy

1. Myocardial Bridging

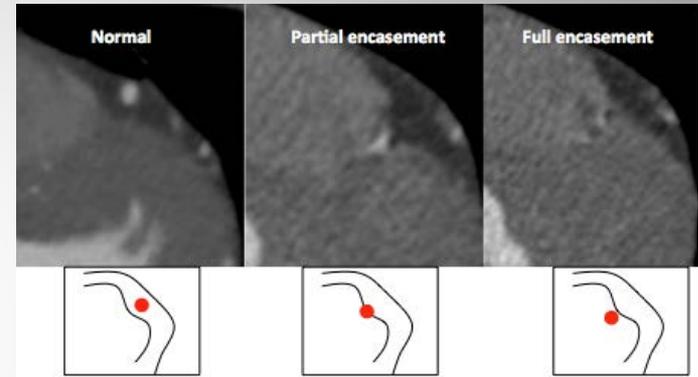
2. Duplication of Arteries

- Rare <1%
- Typically LAD: Short and Long (normal) branches
- Not implicated in sudden adult death
- Significance: Pre CABG

Anomalies of Intrinsic Anatomy: Myocardial Bridging

Band of myocardial muscle overlies coronary artery segment

- Typically mid segment of LAD
- Partial or full encasement



Often better appreciated on CT angiogram as looking for “step down-step up” effect on angiogram

- Incidence on angiogram: 0.25%
- Incidence on CTA: 12%

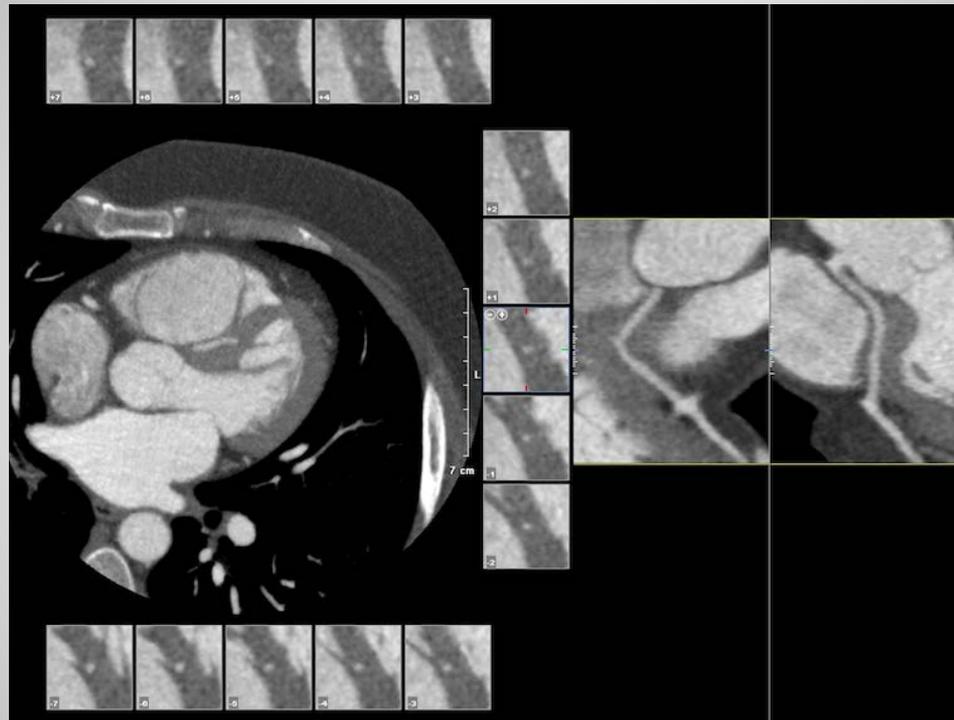
Dynamic obstruction of intramyocardial segment in **systole**

Clinical significance:

- Usually asymptomatic/benign finding
- **Proposed role in sudden cardiac death:** *Episodic ischemia, increased risk of coronary artery disease.*

Anomalies of Intrinsic Anatomy:

Myocardial Bridging



CT coronary angiogram in 34 year old female with chest pain demonstrating segment of myocardium overlying LAD consistent with partial **myocardial bridging**.

Anomalies of Termination

1. Coronary artery fistulation
2. Arcades

Anomalies of Termination:

Coronary Artery Fistulation

Communication between 1/2 coronary arteries and

- Cardiac Chamber
 - RV (45%)
 - RA (25%)
- Coronary Sinus
- SVC
- Pulmonary Artery (15%)

60% RCA
40% LCA
< 5% Both

Dilated tortuous coronary artery due to increased blood flow and shunting

Clinical significance:

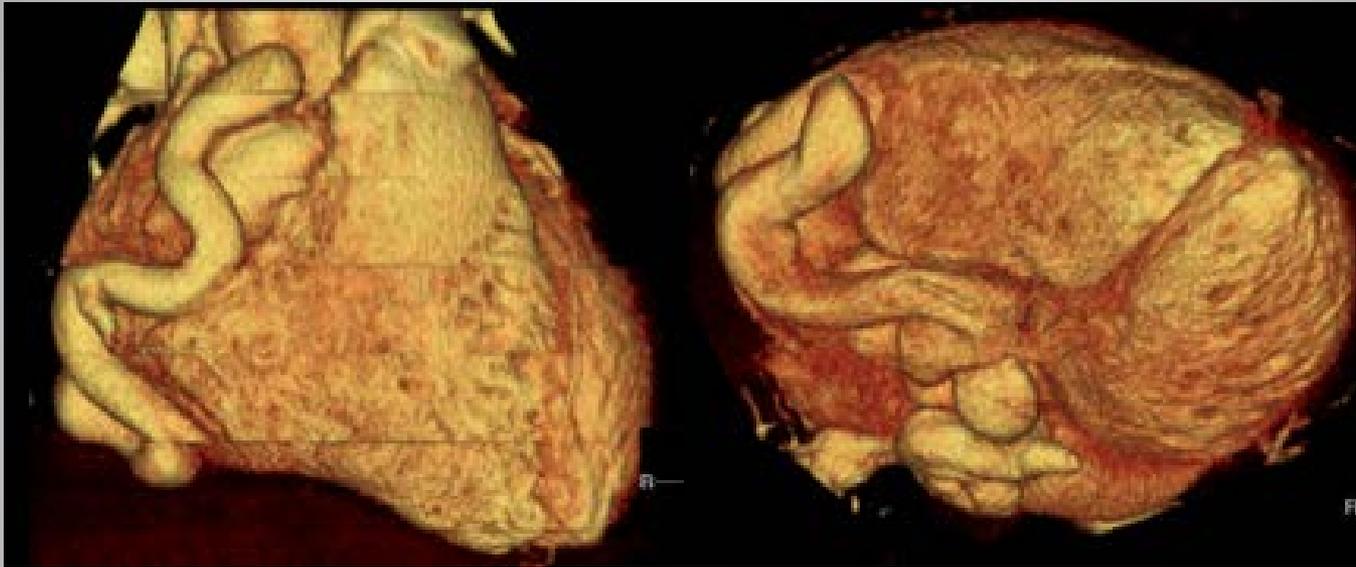
When fistula leads to

- Right Chamber: L-R shunt
- Left Chamber: Analogous to Aortic Regurgitation

Proposed role in sudden cardiac death: *Reduced myocardial perfusion in portion of myocardium supplied by abnormally connecting coronary artery which can lead to secondary ischaemia and arrhythmias; volume overload*

Anomalies of Termination:

Coronary Artery Fistulation



49 year old female presenting with chest pain and NSTEMI:
RCA demonstrating communication to coronary sinus compatible with fistula

Anomalies of Termination:

Arcades



Connection of RCA and LCA with straight vessels in absence of coronary stenosis

- DDx: collaterals but typically tortuous

Better appreciated on CTA

Not typically implicated in sudden cardiac death

Conclusion

- Coronary artery anomalies are rare however implicated in 19% of sudden adult deaths
- CT coronary angiography characterizes anomalies better than conventional angiography
 - Also useful in screening population
- Knowledge of basic coronary artery anatomy is key
- If abnormality, is it based at
 - **Origin**
 - **Intrinsic course**
 - **Termination**
- Importance of **interarterial course**
 - Haemodynamically significant
 - Associated with episodic spasm: proposed hypothesis of sudden adult death

References

Coronary artery anomalies: Classification and ECG-gated Multi-Detector row CT findings with Angiographic correlation

Kim SY et al.. *RadioGraphics*(2006) 26(2), pp. 317–333. doi: 10.1148/rg.262055068.

Coronary artery anomalies

Angelini, P. *Congenital Heart Disease for the Adult Cardiologist* (2007), 115(10), pp. 1296–1305. doi: 10.1161/CIRCULATIONAHA.106.618082.

Identifying, characterizing, and classifying congenital anomalies of the coronary arteries

Shriki J et al *RadioGraphics* (2012) 32(2), pp. 453–468. doi: 10.1148/rg.322115097

Further Questions?

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