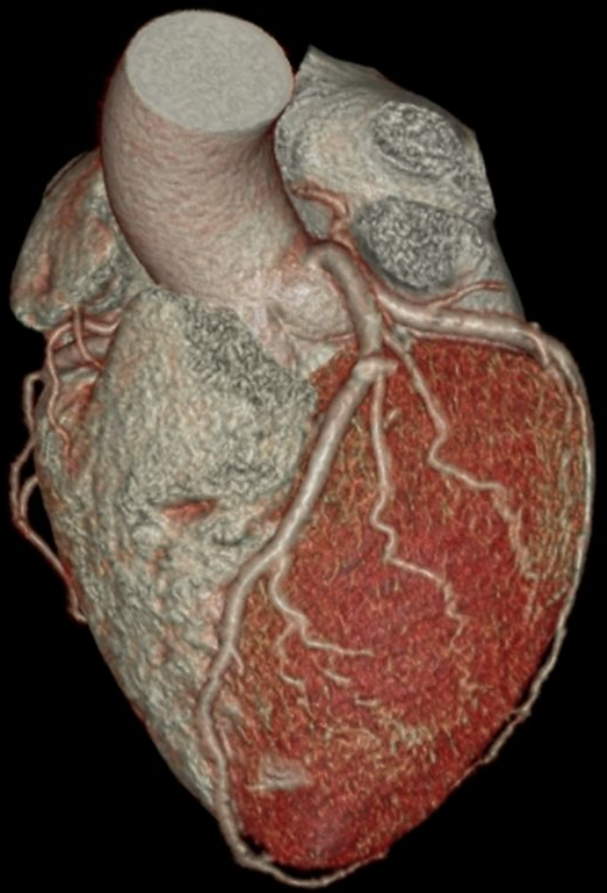
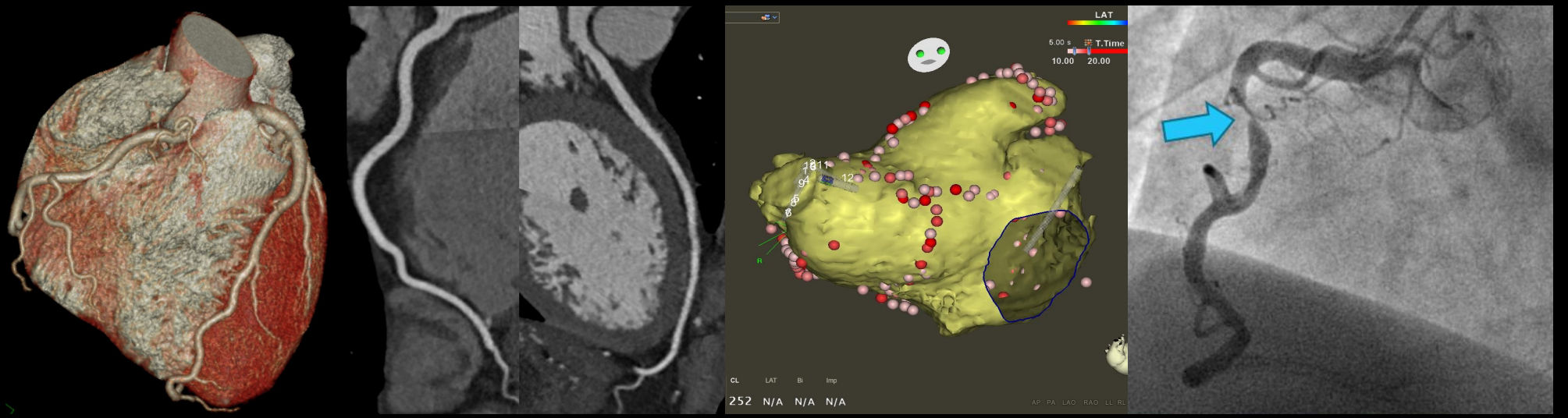
The role of CT in the diagnosis of cardiovascular diseases



CIRG
MTA-SE „Lendület"
Kardiovaszkuláris
Képalkotó Kutatócsoport

2019

I. Coronary CT angiography



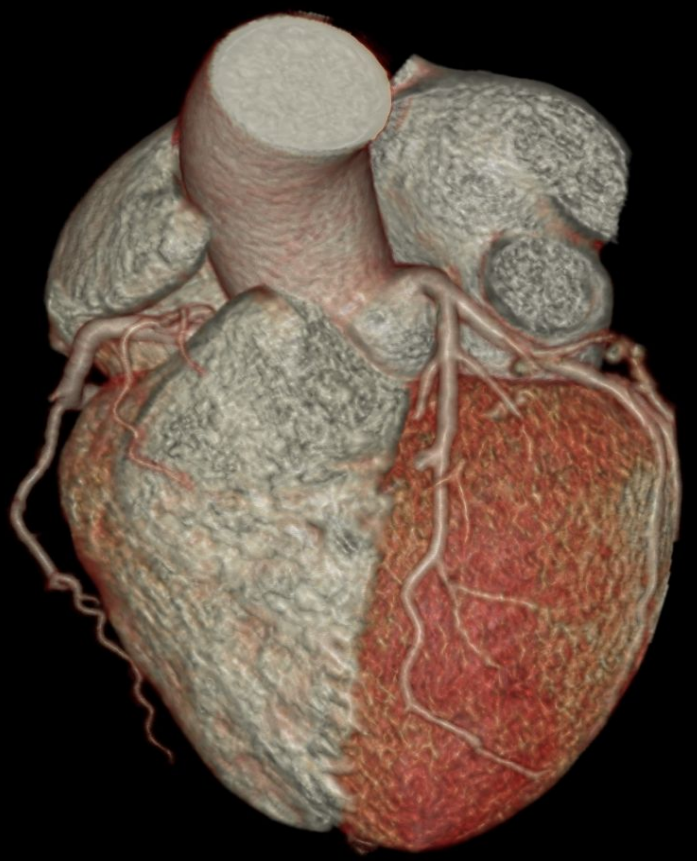
Diagnostic performance

Sensitivity: 92%

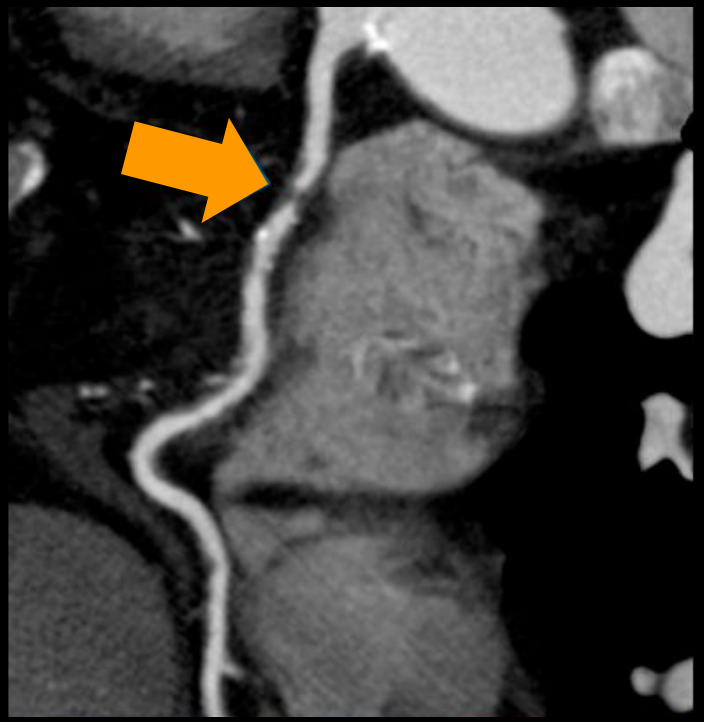
Specificity: 79%

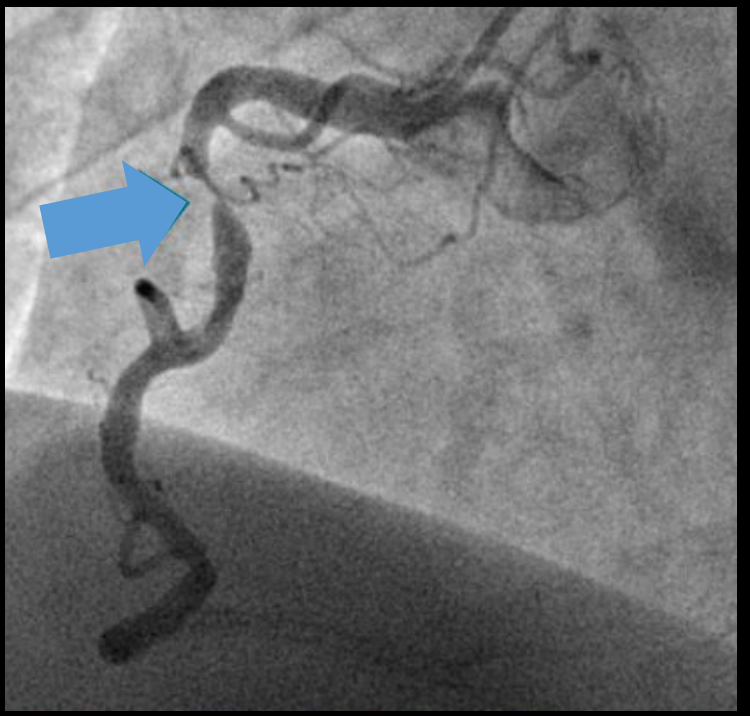
Pozitive predictive value: 90%

Negative predictive value: 99%



CCTA vs. ICA





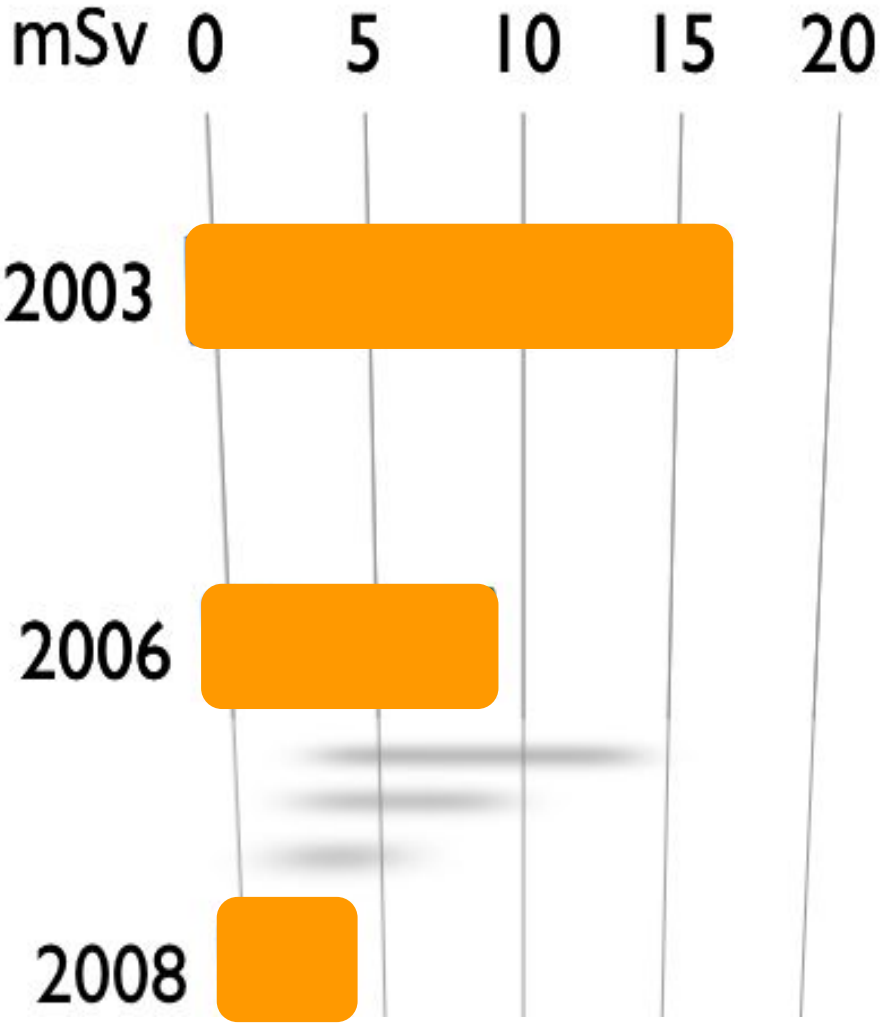
- Non-invasive
- Spacial resolution: 0,4 mm
- Temporal resolution: 75-200 ms
- Intravenous contrast media
- Intervention not possible

- Minimally invasive
- Spacial resolution: 0,2 mm
- Temporal resolution: 8 ms
- Intracoronary contrast media
- Intervention possible

Radiation dose

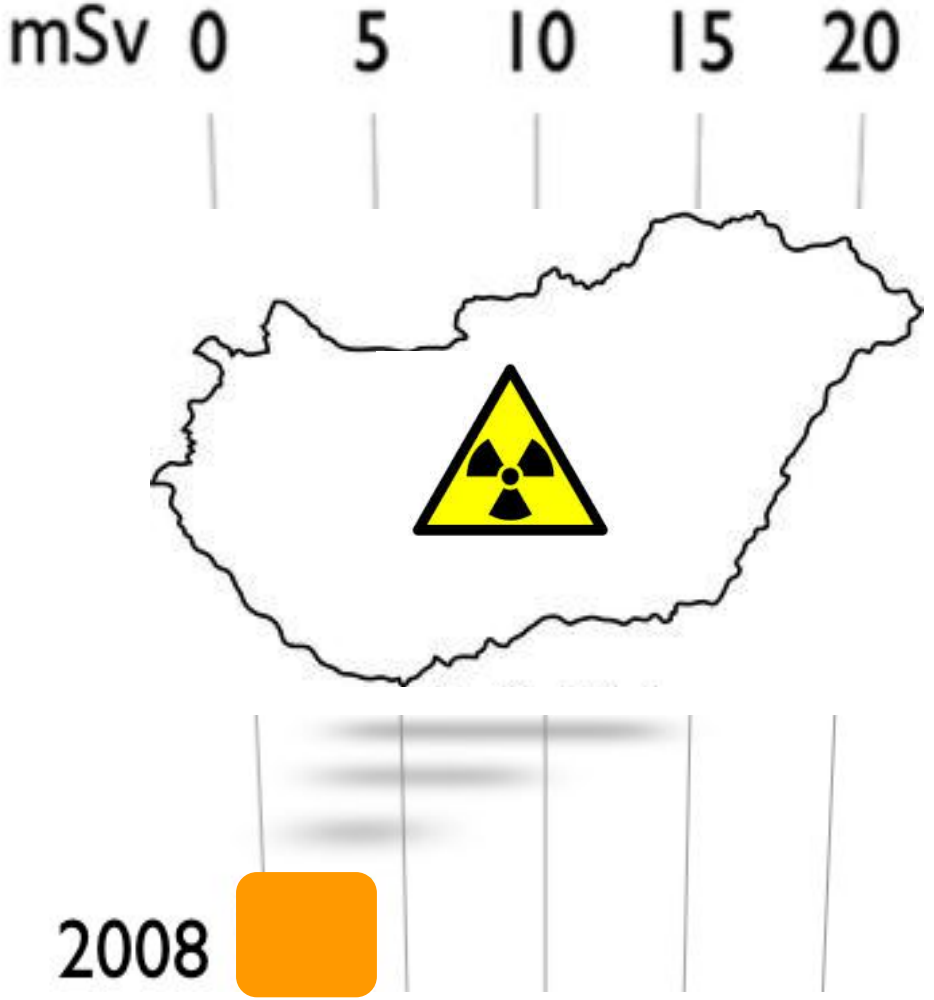
3-4 mSv, which approximates the annual background radiation measurable in Hungary

Prospective ECG gating



Radiation dose

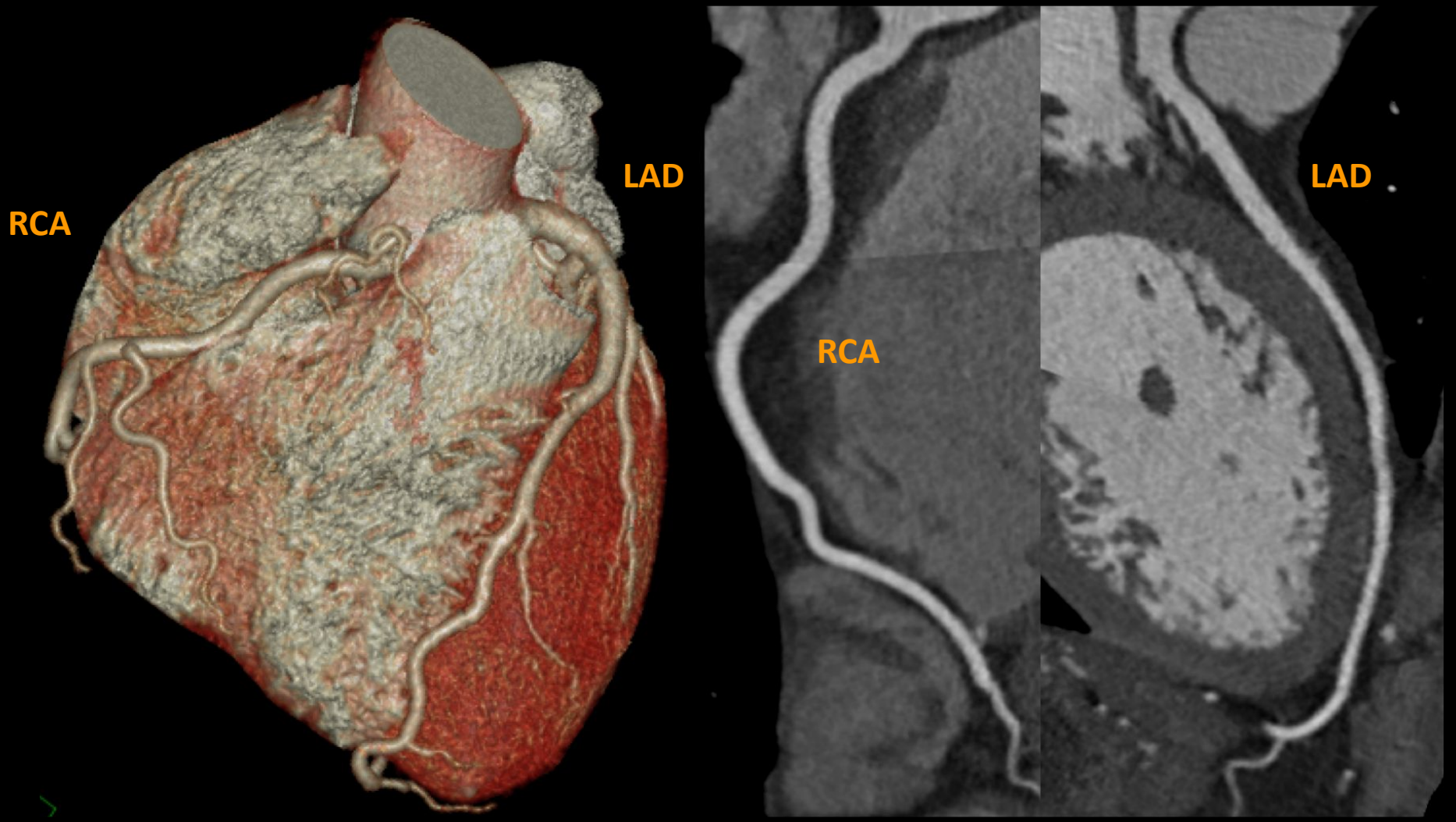
3-4 mSv, which approximates the annual background radiation measurable in Hungary



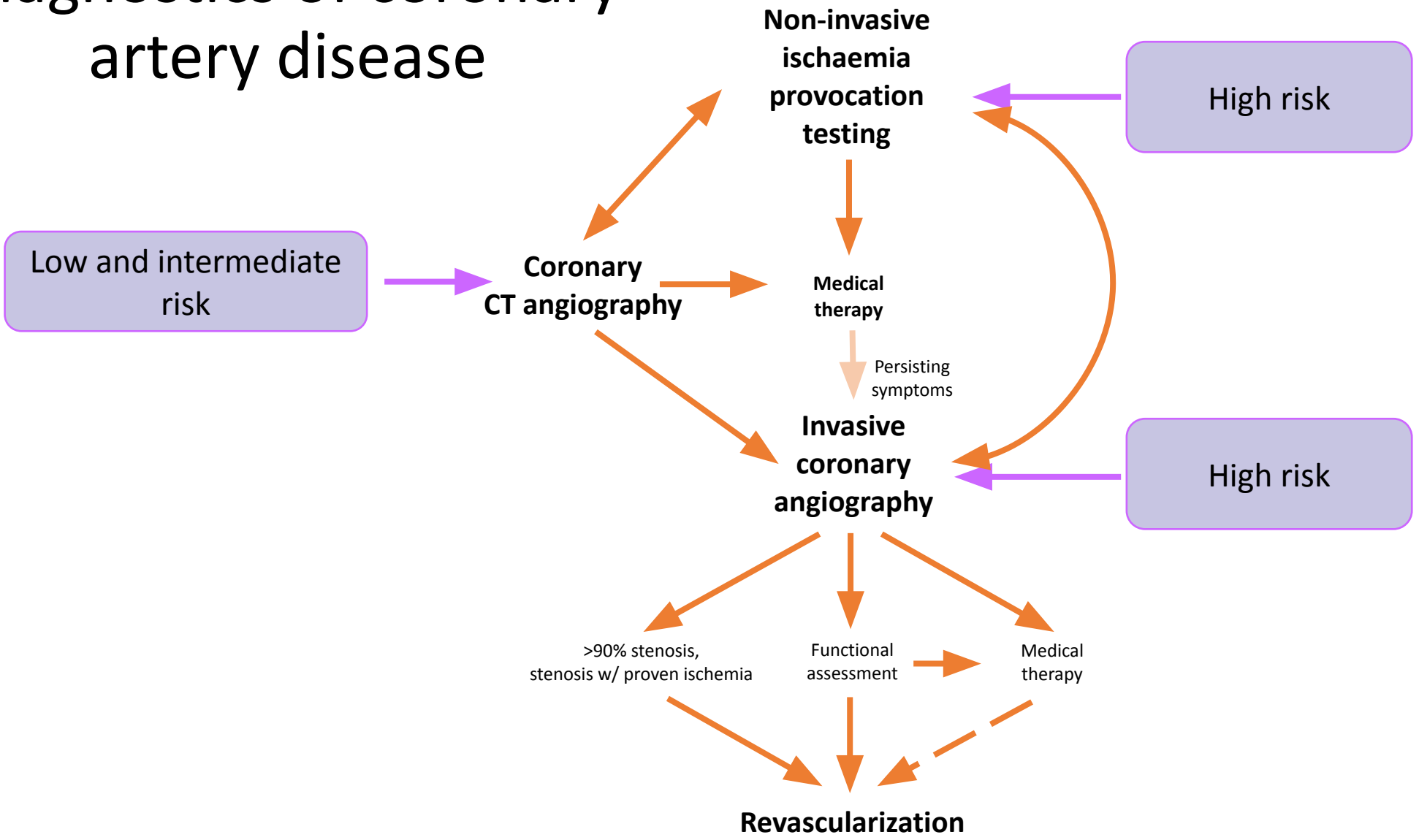
Prospective ECG gating

Indications

1. Exclusion of coronary artery disease in the case of patiens with chest symptoms and low to intermediate risk

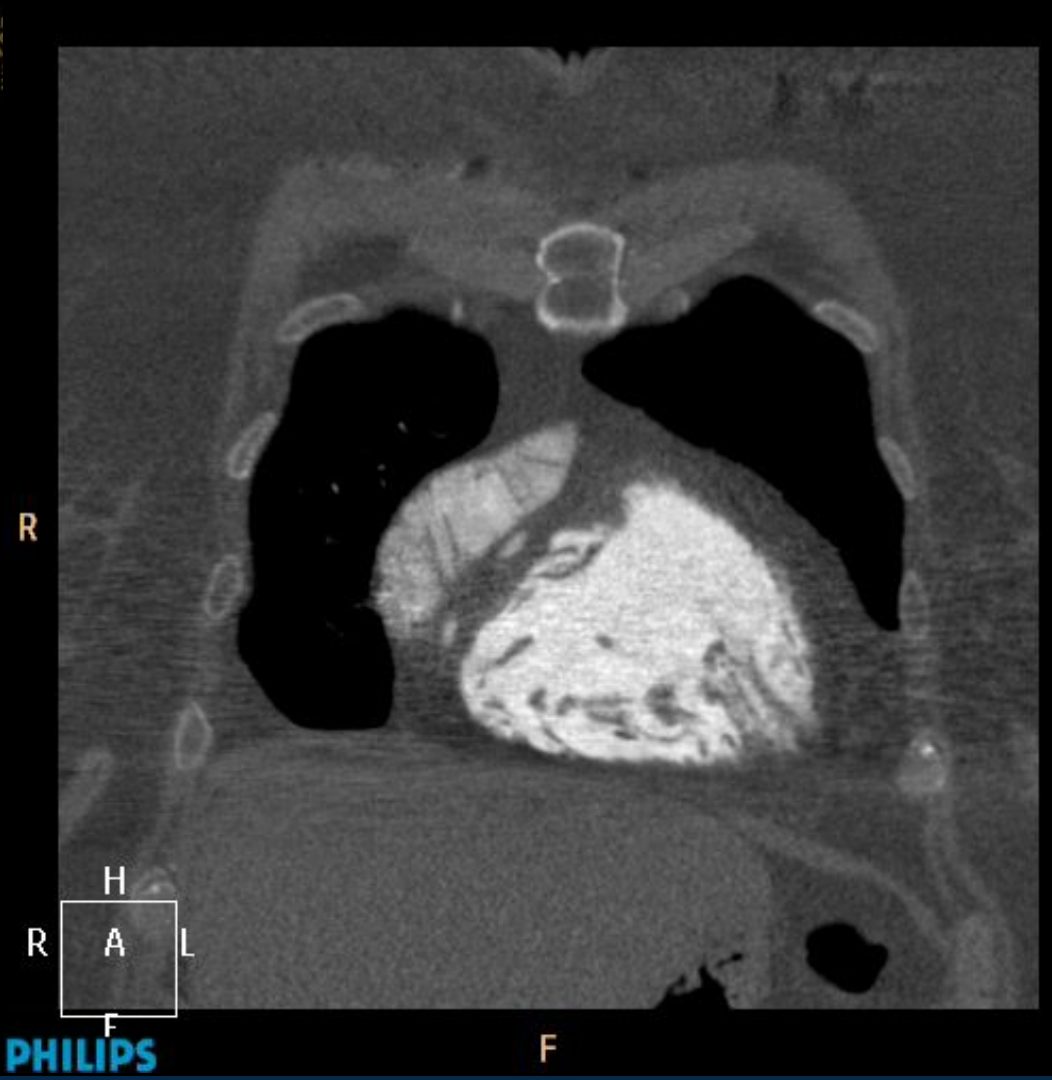


Diagnostics of coronary artery disease

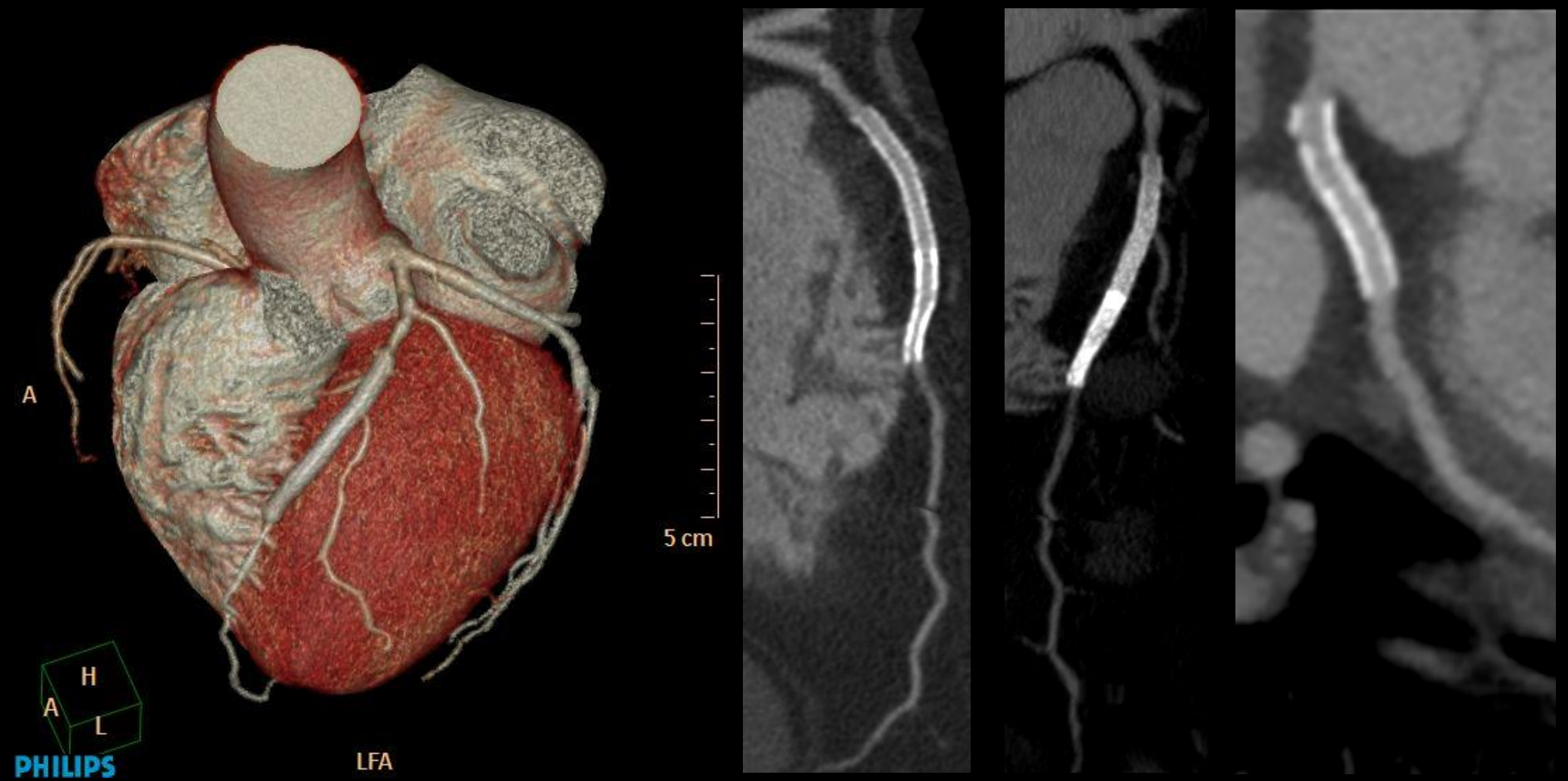


2. Inclusive ischemia testing

3. Acute chest pain - “Triple rule out”

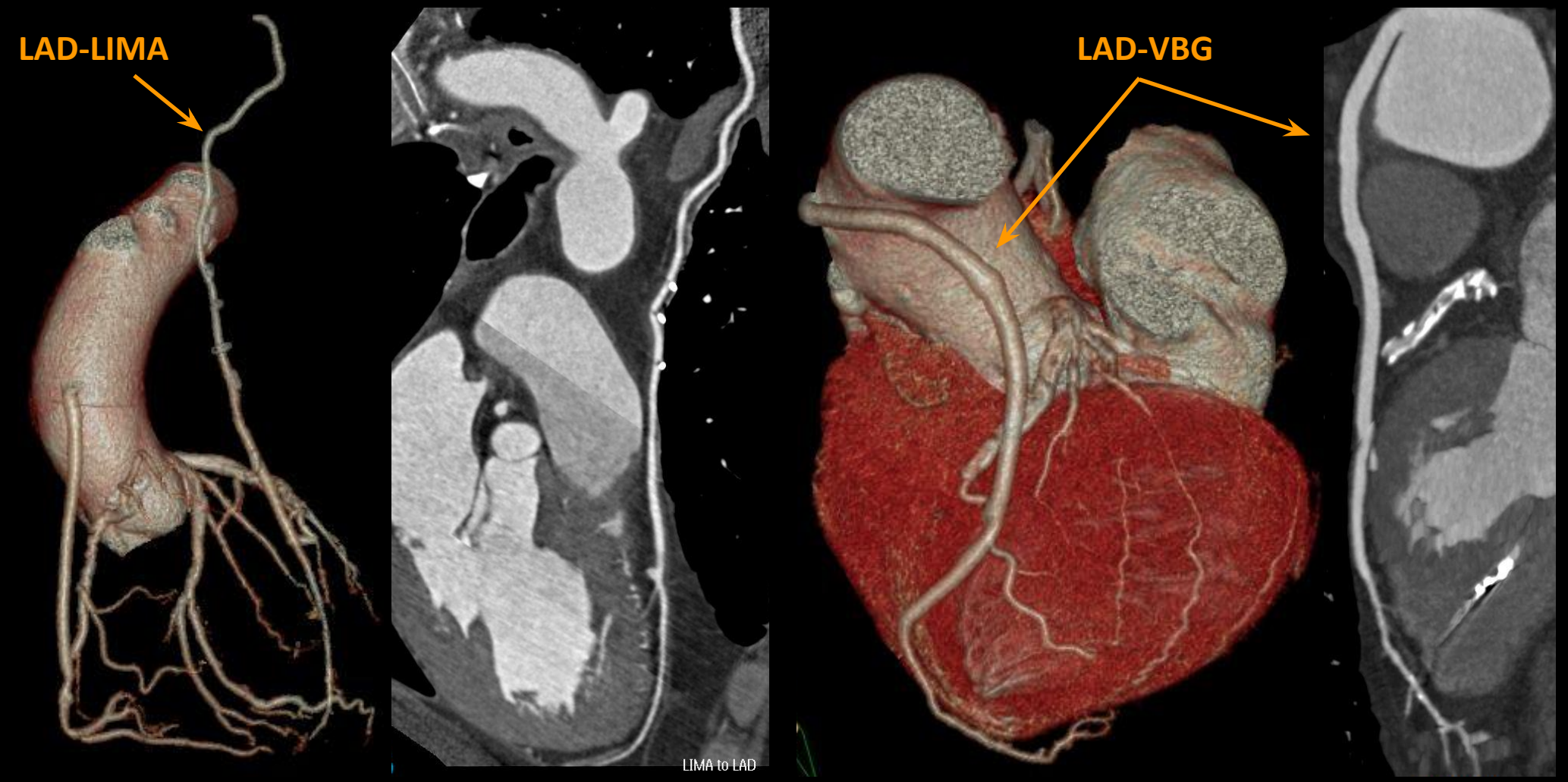


4. Assessment of coronary stents (>3 mm)



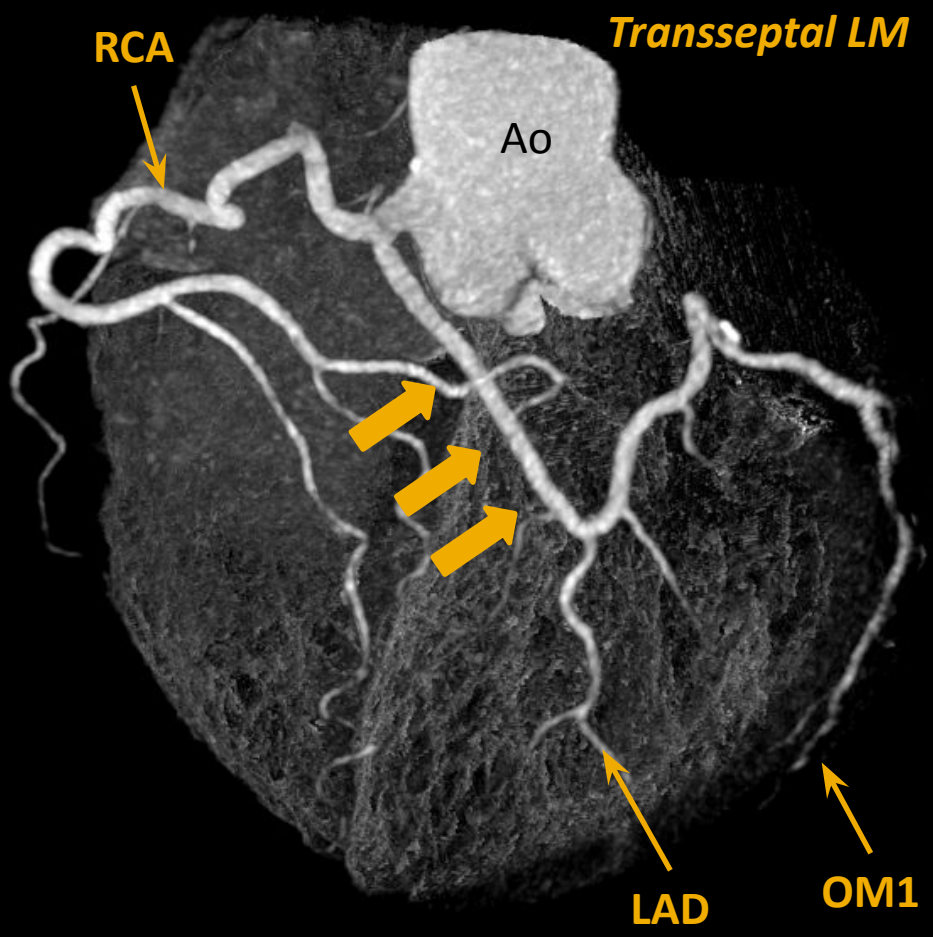
5. Assessment of bypass grafts

	Sens. (%)	Spec. (%)
Venous grafts	98	97
Native vessels (9% not assessable)	86	76



6. Detection of coronary anomalies

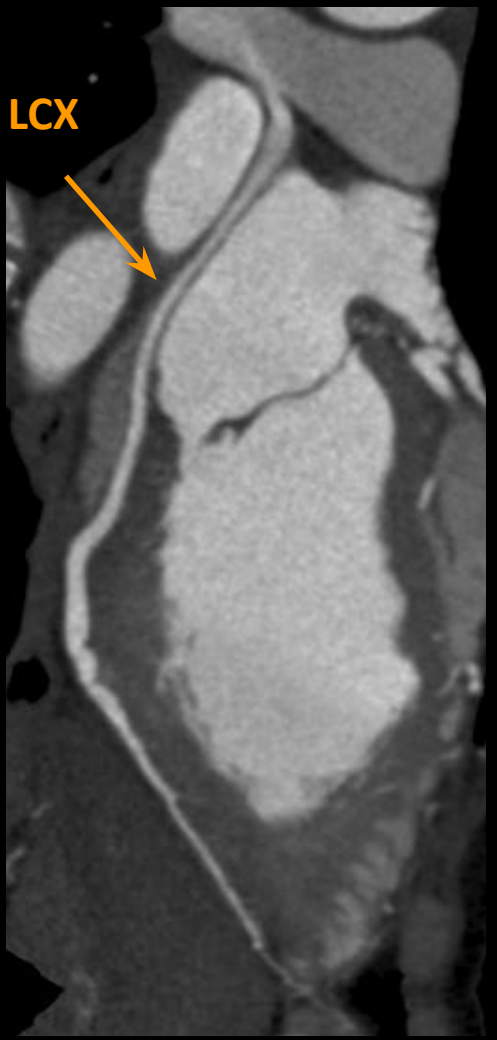
Benign:



Detection of coronary anomalies

Malignant:

ALCAPA



Interarterial LM

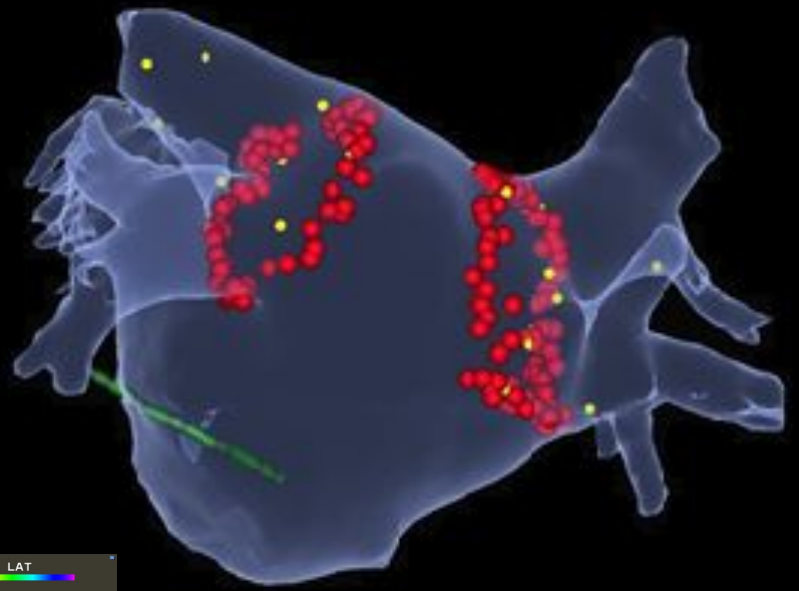
RCA

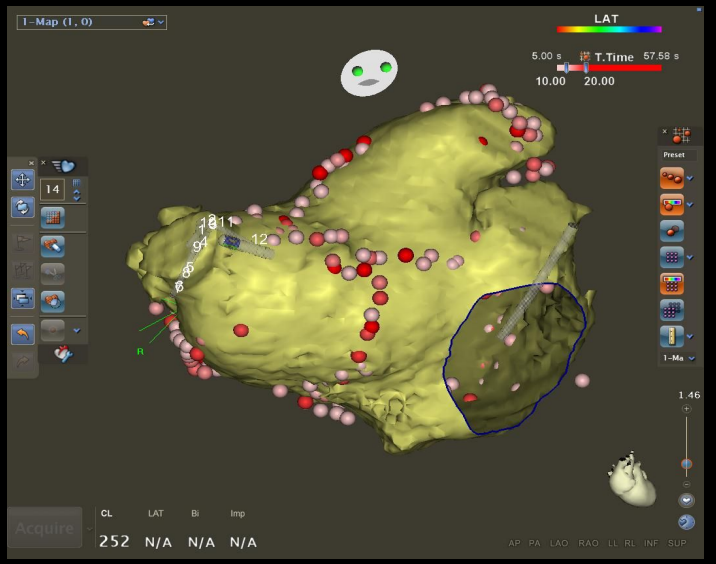
LAD

D1

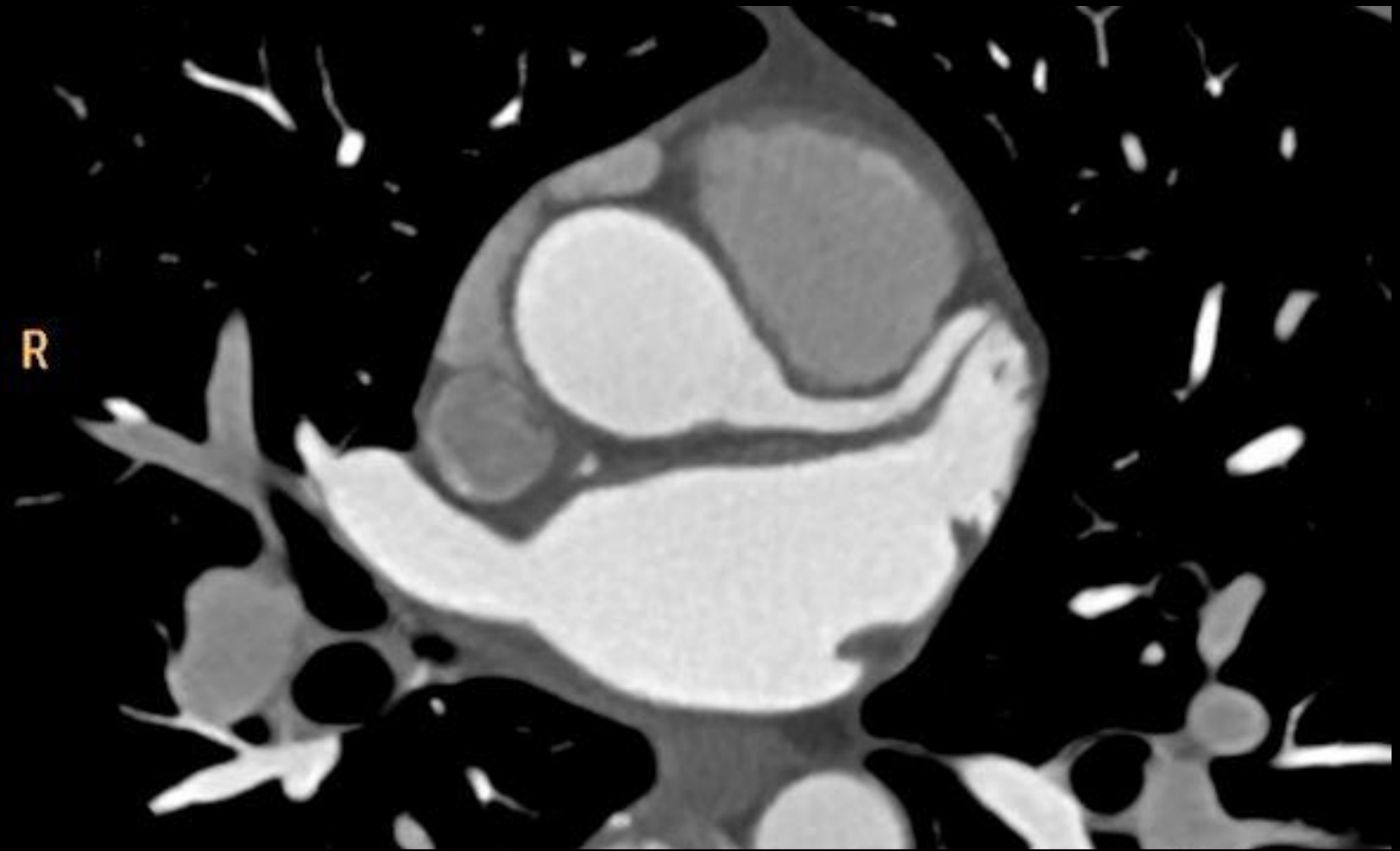
OM1

7. Left atrial CT angiography

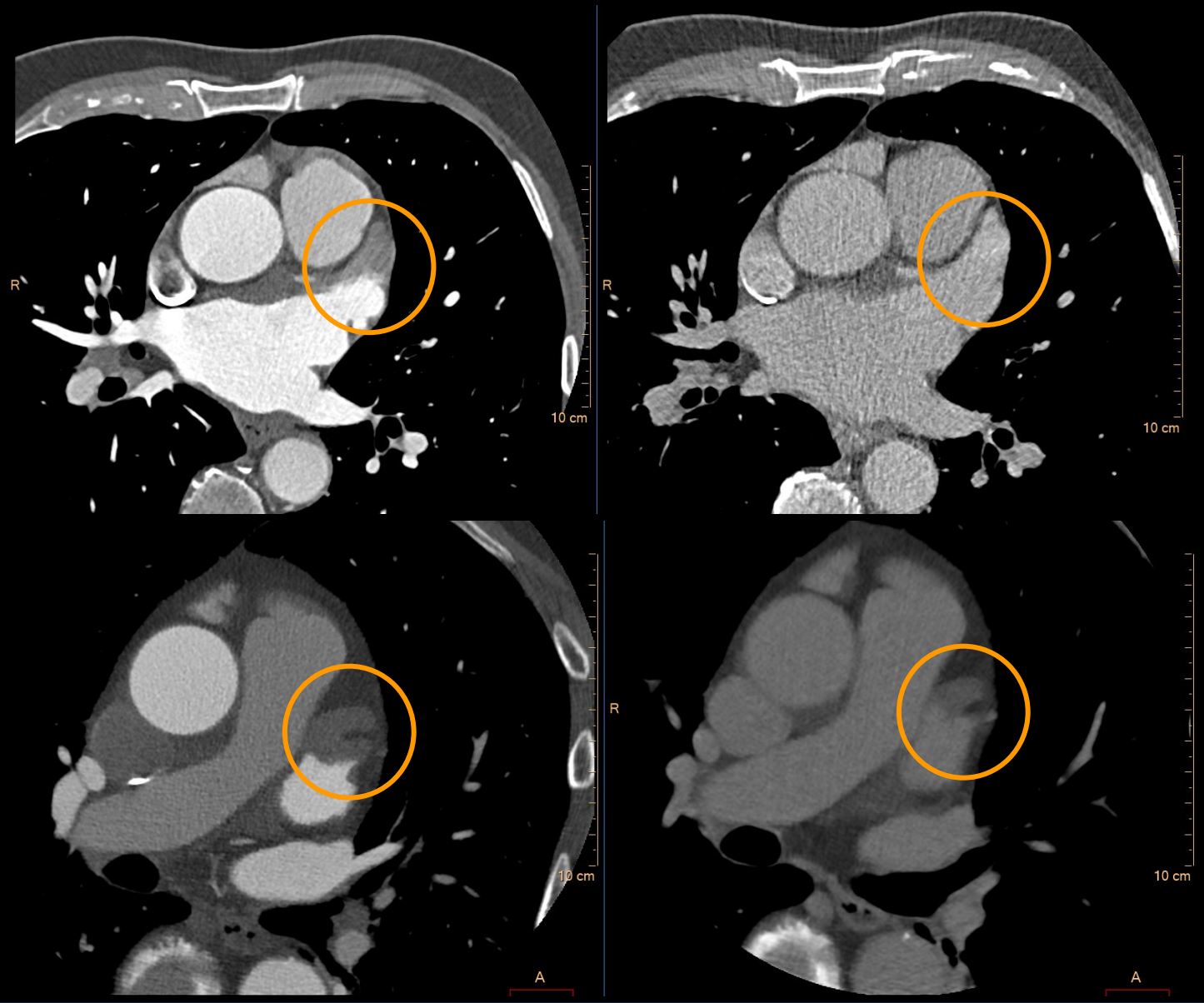




Exclusion of thrombus in the left atrial appendage

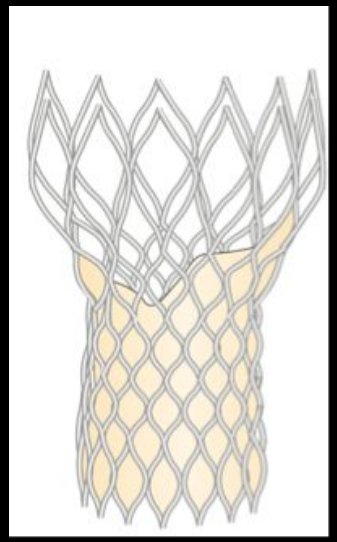


Left appendage thrombus vs. contrast filling artifact

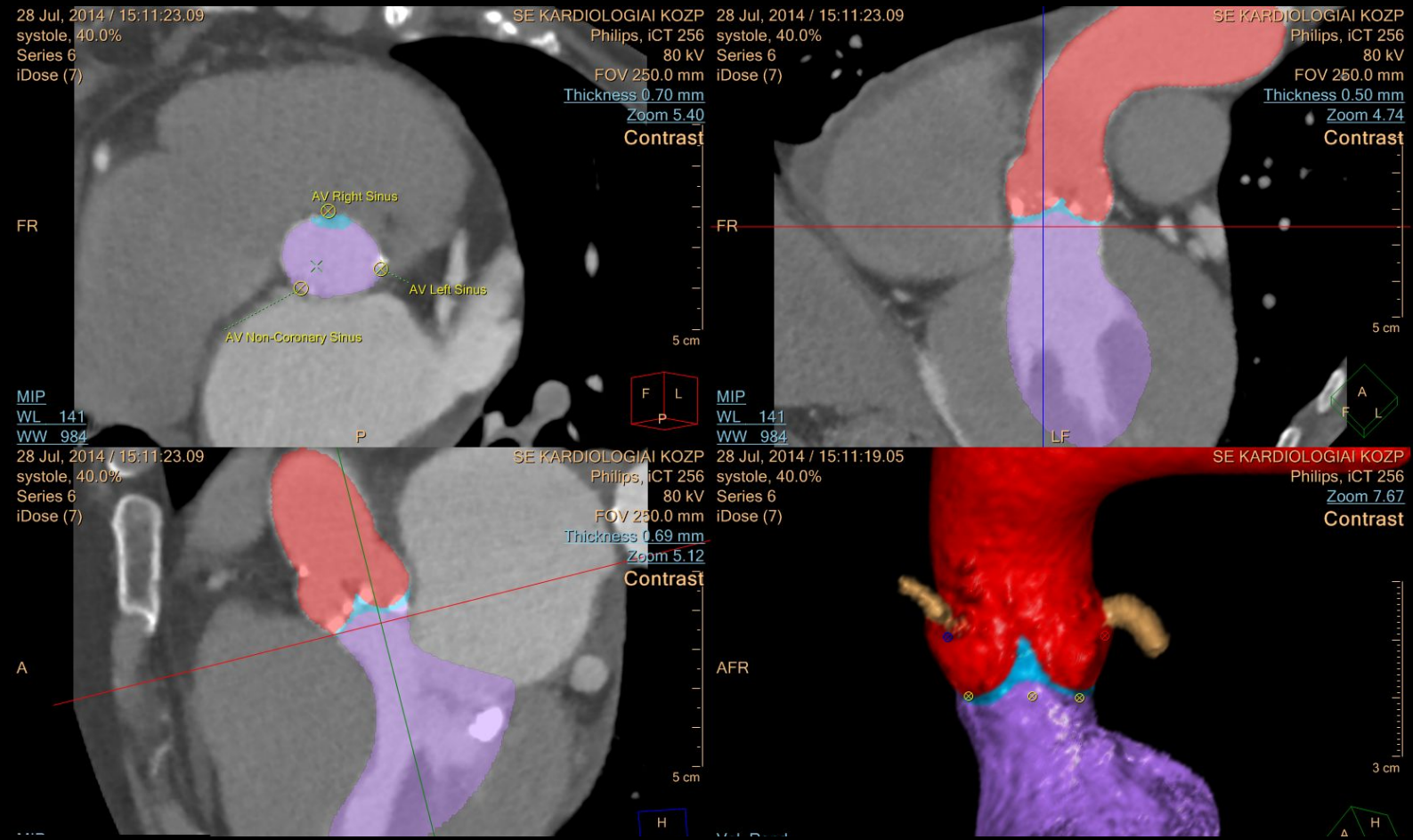


8. Structural intervention planning

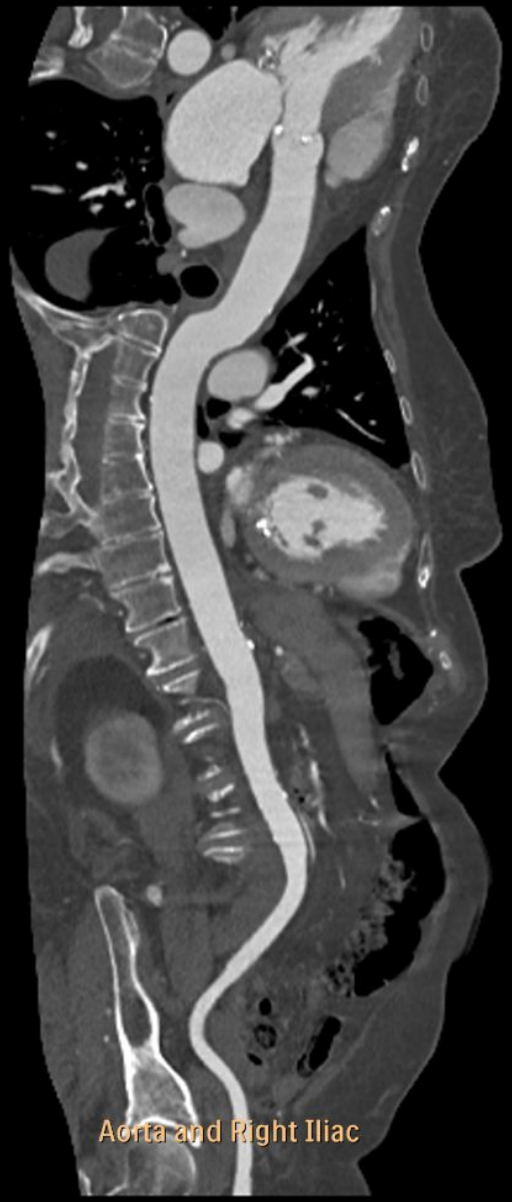
TAVI planning



CoreValve® system



TAVI planning



The course of the examination

CCTA contraindications

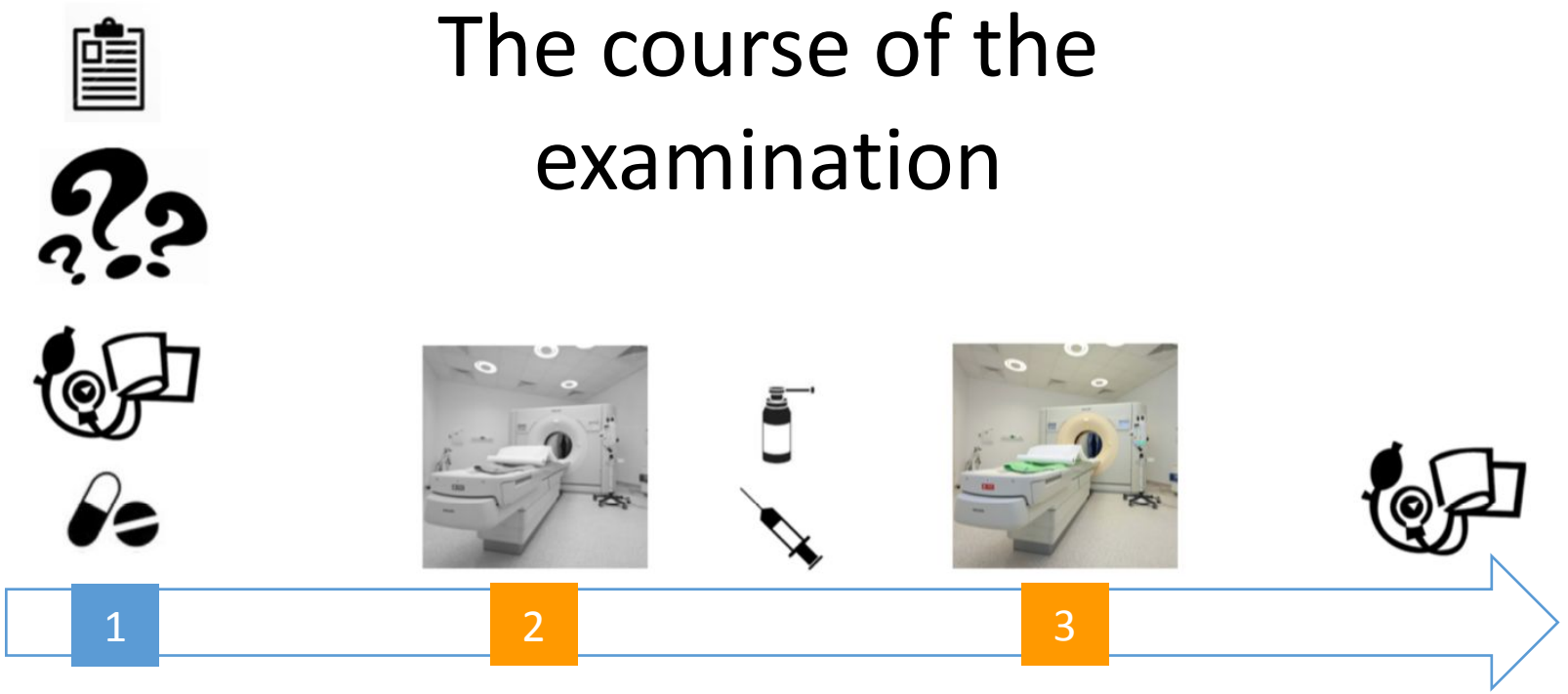
Relative contraindications

- Obesity (BMI >39kg/m^2)
- Irregular heart rhythm
- Tachycardia
- Contraindication of Beta-blocker premedication
- Contraindication of NLG premedicaton
- Difficulty with breath hold
- Difficulty with body positioning

Absolute contraindications

- Known contrast media hypersensitivity
- Inability to cooperate / hold breath
- Pregnancy
- Renals insufficiency (eGFR<30)
- Unstable haemodynamic status (AMI, severe hypotension, decompensated heart failure)

The course of the examination



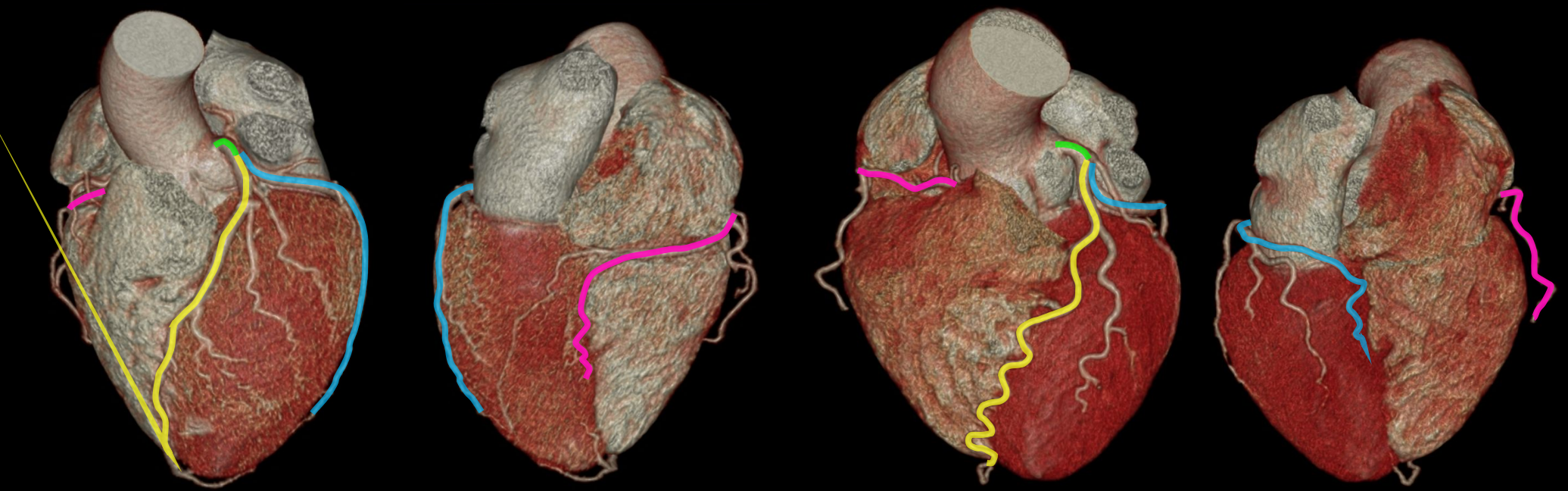
2. Native image acquisition
   +nitrate, metoprolol iv.
3. Contrast enhanced image acquisiton

Image evaluation

Coronary anatomy

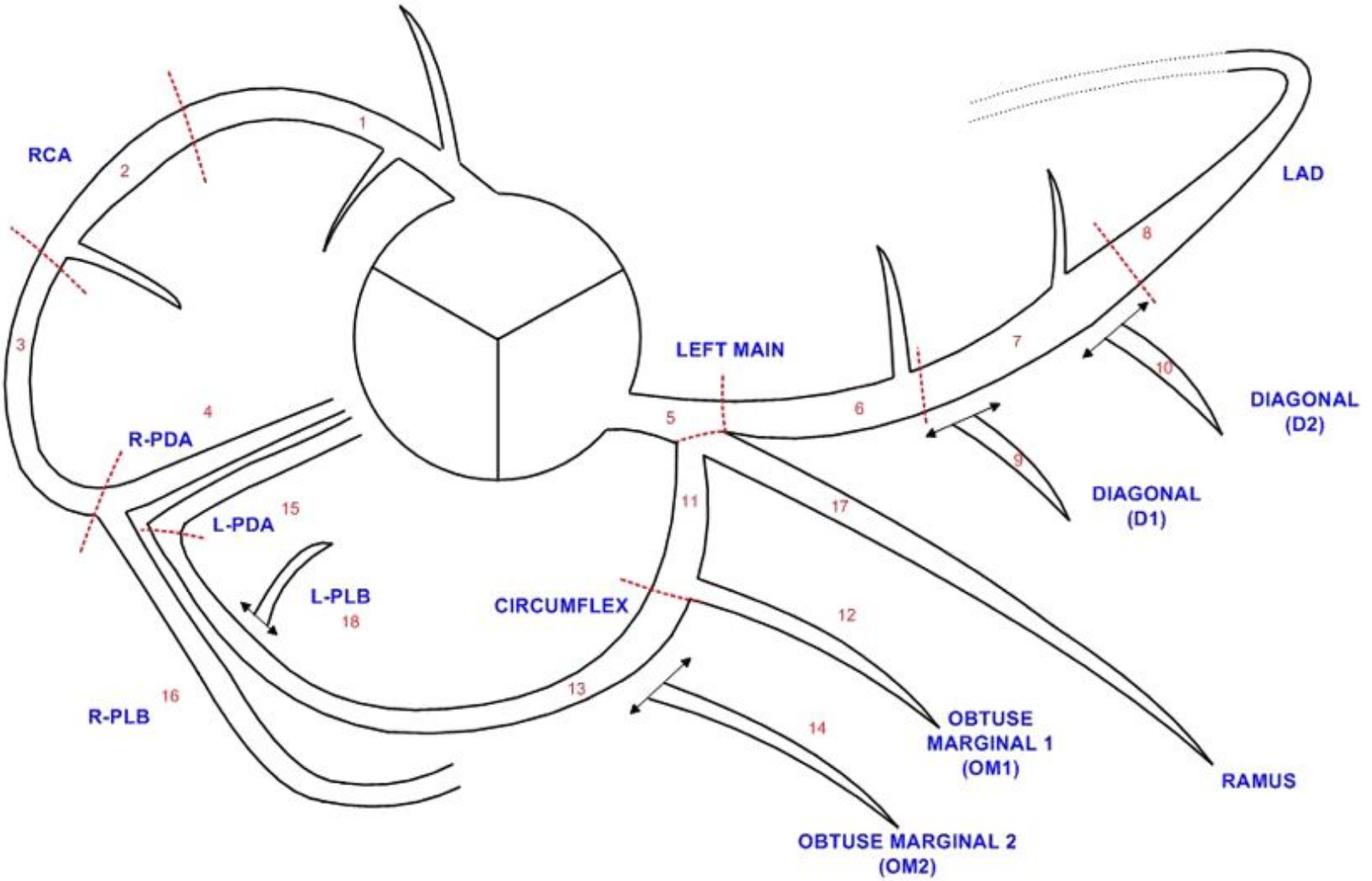
Right dominant

Left dominant

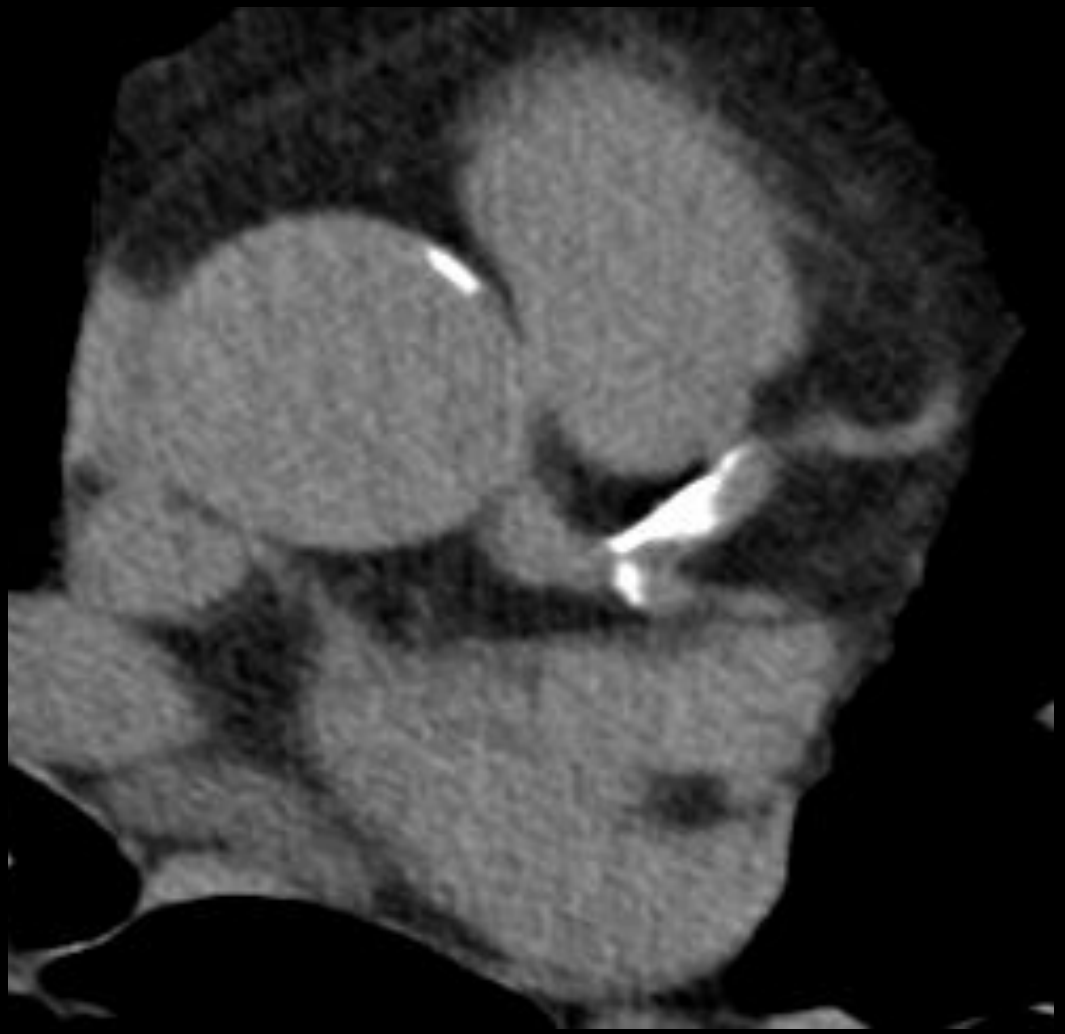


- Left main coronary (LM)
- Left anterior descending artery (LAD)
- Left circumflex artery (LCX)
- Right coronary (RCA)

Axial coronary anatomy



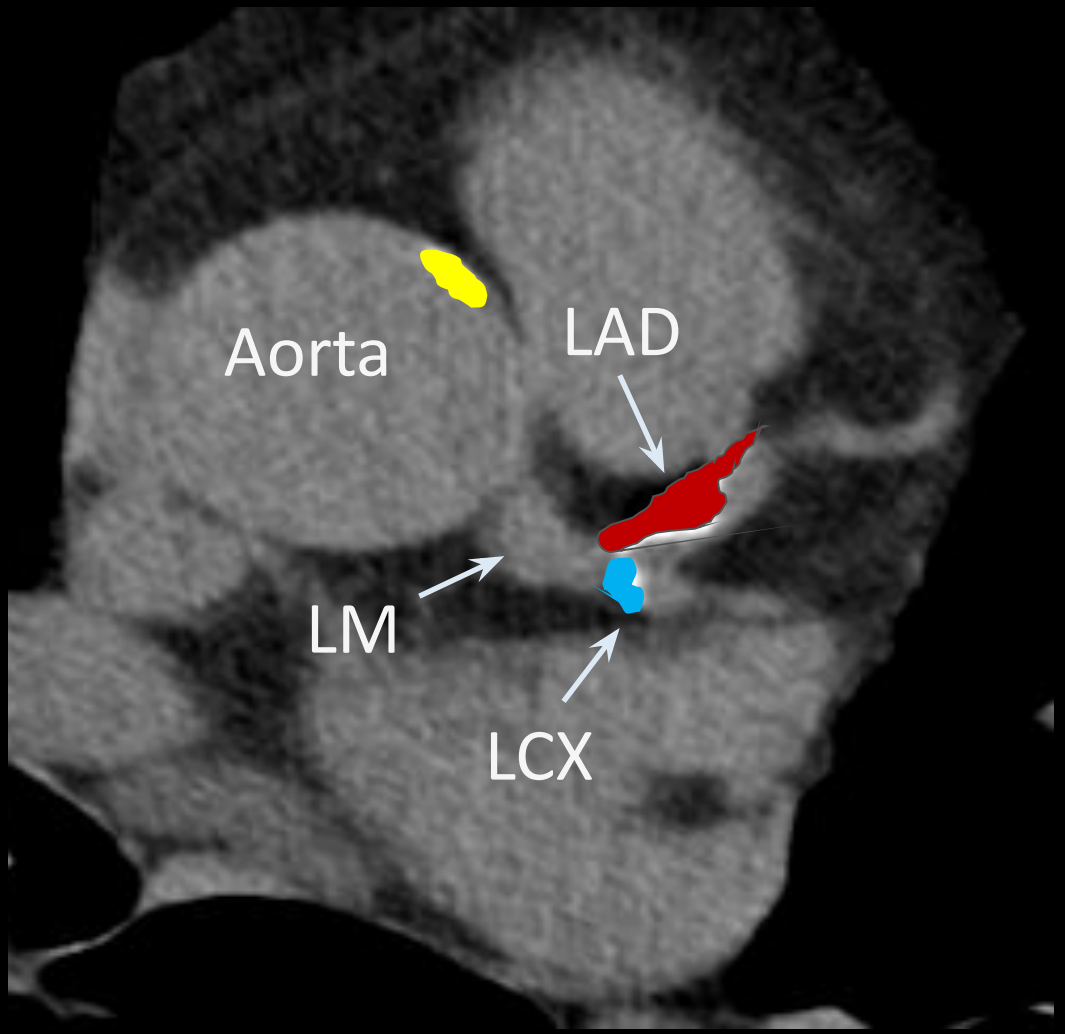
Ca-score



- The product of the area of calcified plaque (mm2) and the coefficient determined on the highest density value measured within the plaque (HU)
- Coefficient 1-4: 1: 130-199 HU
  2: 200-299 HU
  3: 300-399 HU
  4: ≥400 HU
- Calcified lesion detection threshold: 130 HU, ≥ 1 mm^2

Example:
The max. density of a calcified lesion is 400 HU, area 8 mm2 → Ca-score: 4x8 = 32

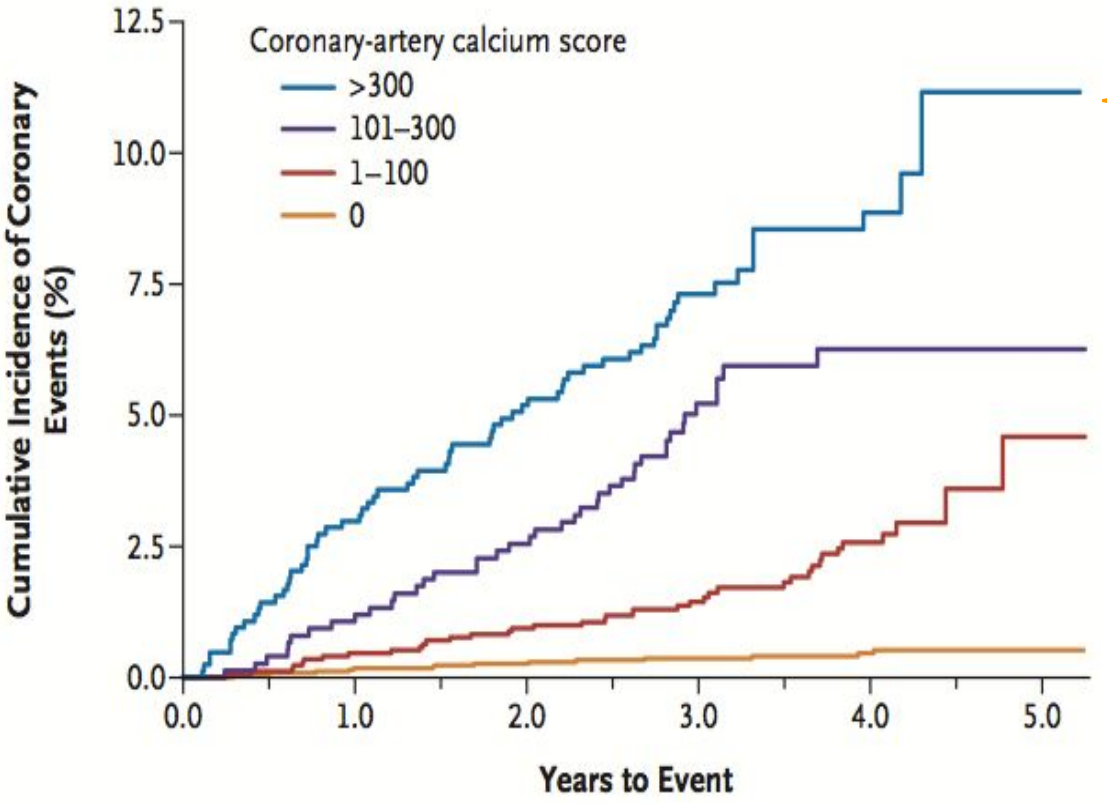
Ca-score



AGATSTON SCORE				
LM	LAD	LCX	RCA	TOTAL
0	258.9	97.6	0	356.5

Intermediate risk

Ca-score

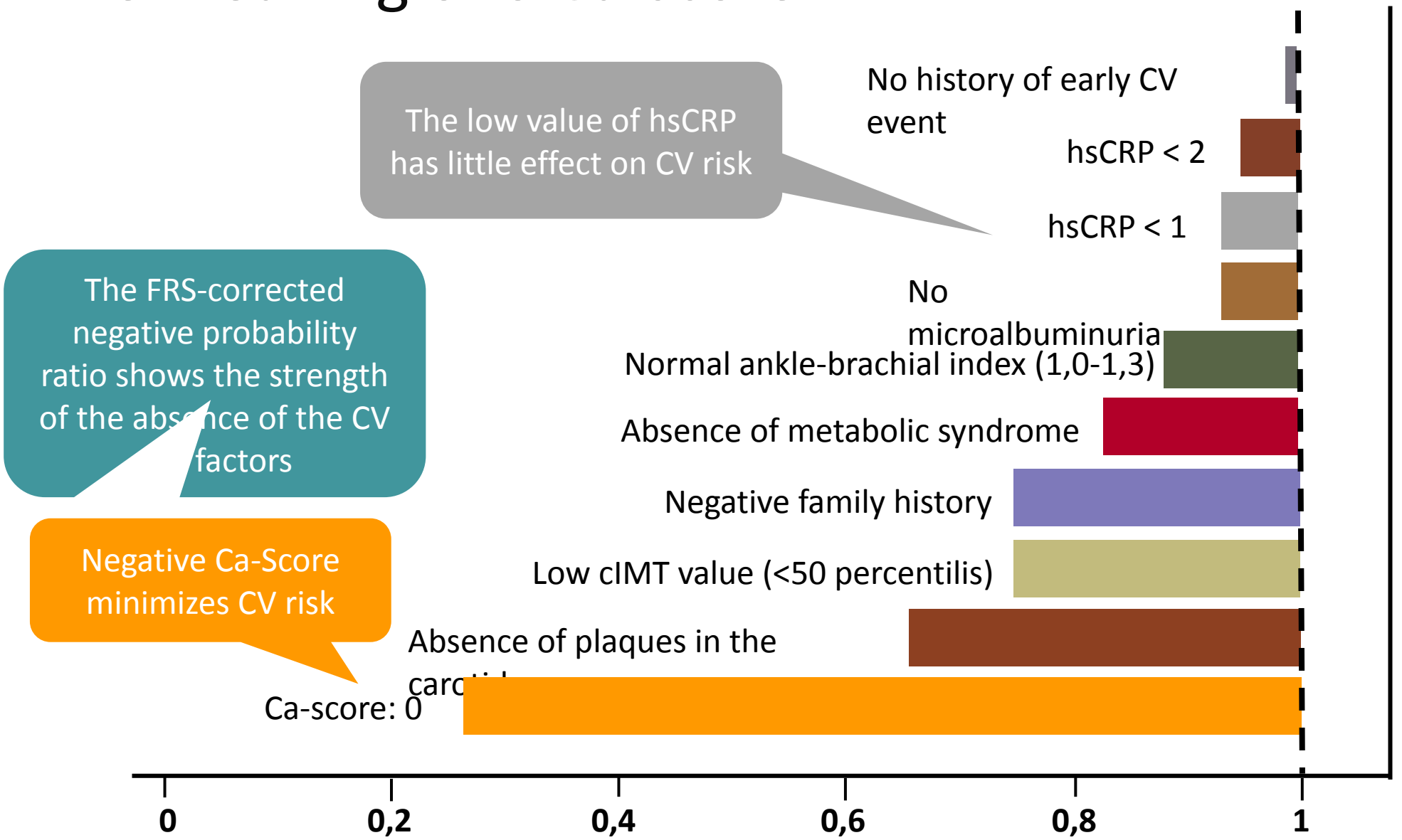


3-10x increase in CV events

SCORE	RISK
0	None
0-99	Low
100-399	Intermediate
400-999	High
≥1000	Extreme high

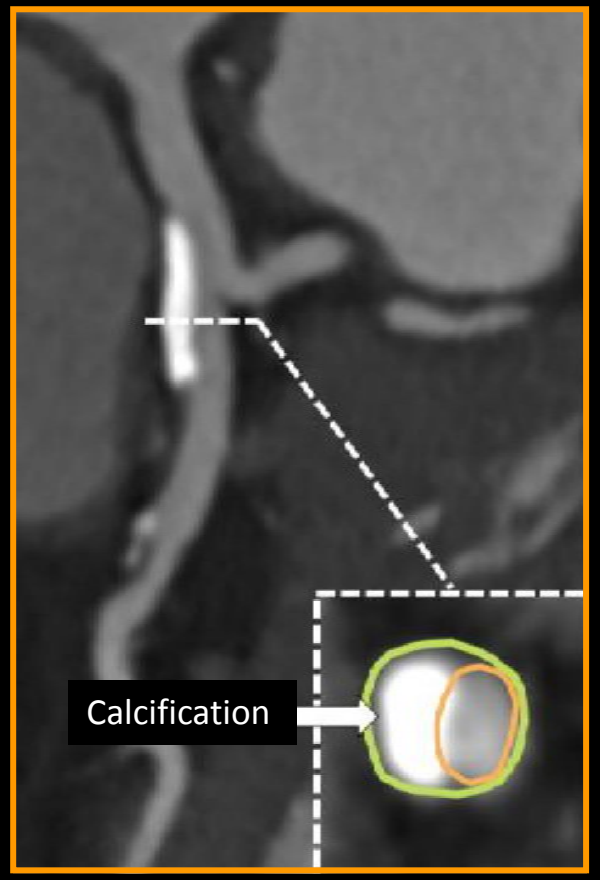
Detrano et al. NEJM 2008;358:1336-45
Budoff et al., J Am Coll Cardiol. 2007

The meaning of 0 Ca-score

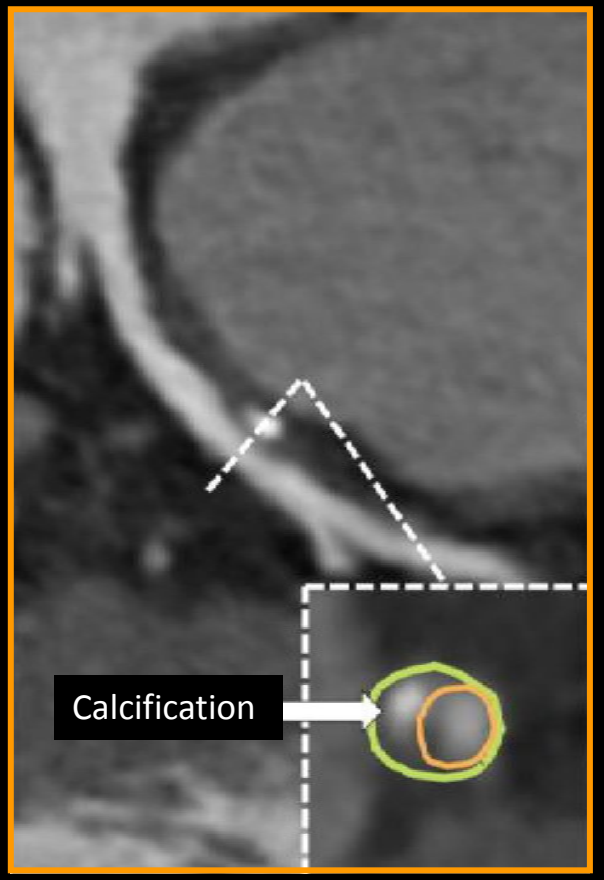


Blaha et al., AHA 2014

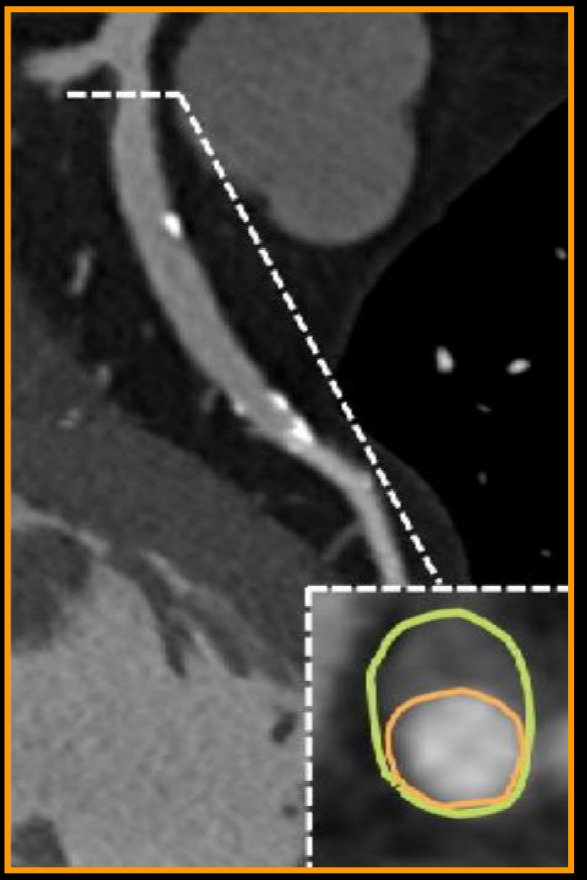
Plaque types



Calcified



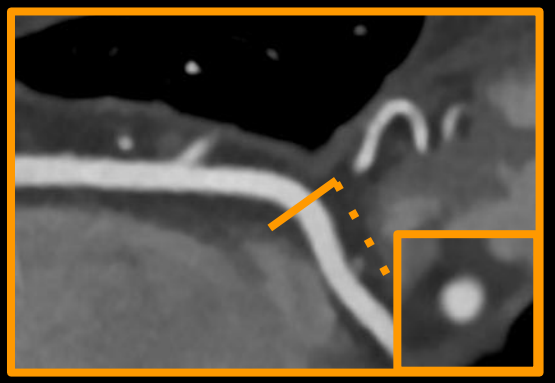
Partially calcified



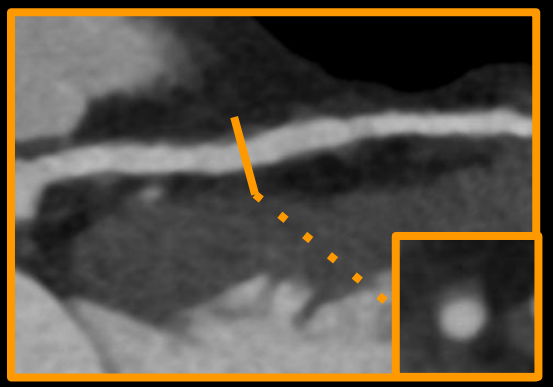
Non-calcified

Stenosis grading

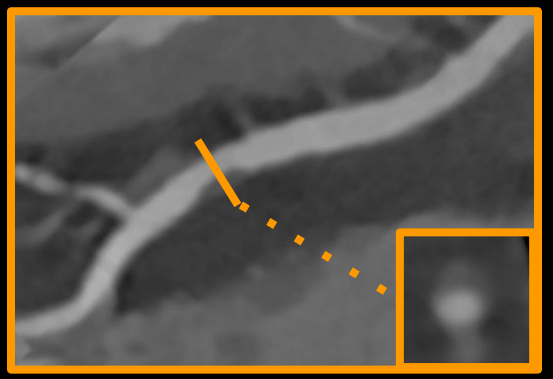
Normal
(0%)

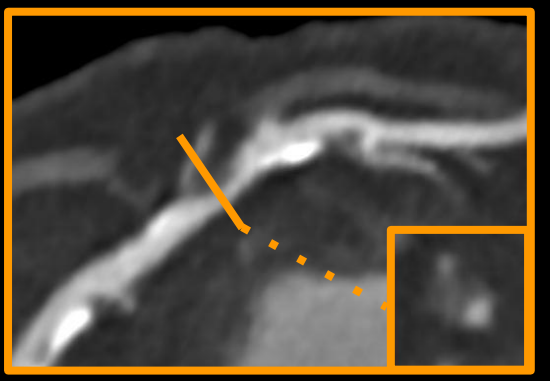


Minimal
(1-24%)

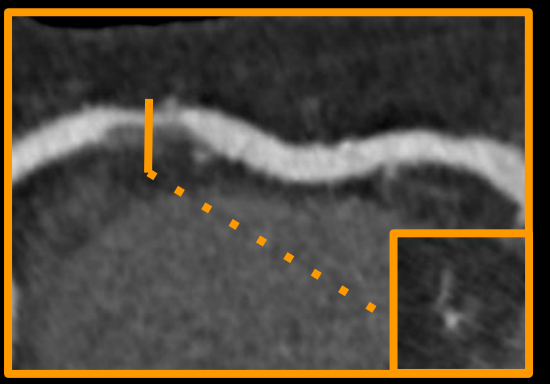


Mild
(25-49%)

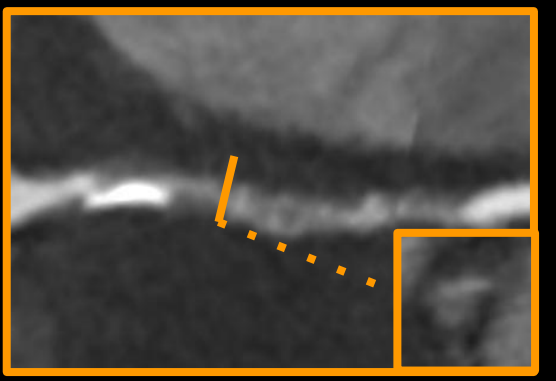




Moderate
(50-69%)



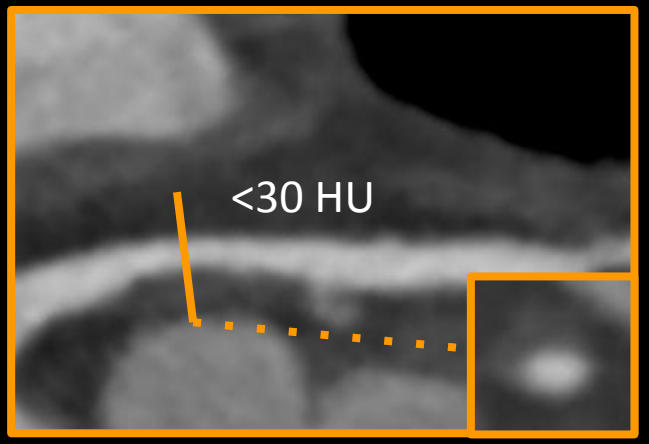
Severe
(70-99%)



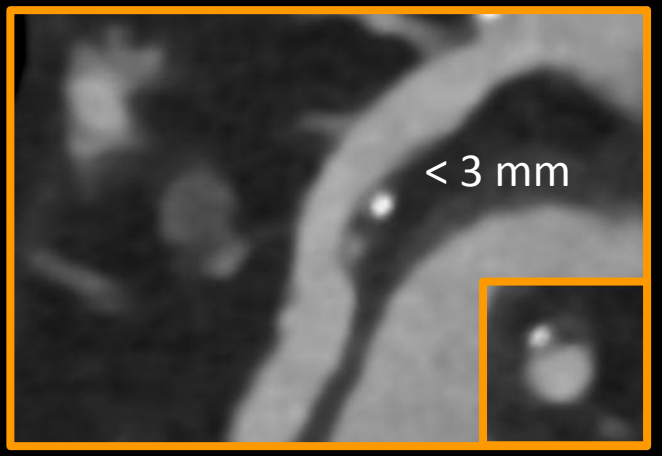
Occlusion
(100%)

Kolossvary, M., et al., Cardiovasc Diagn Ther, 2017

Vulnerable plaque features

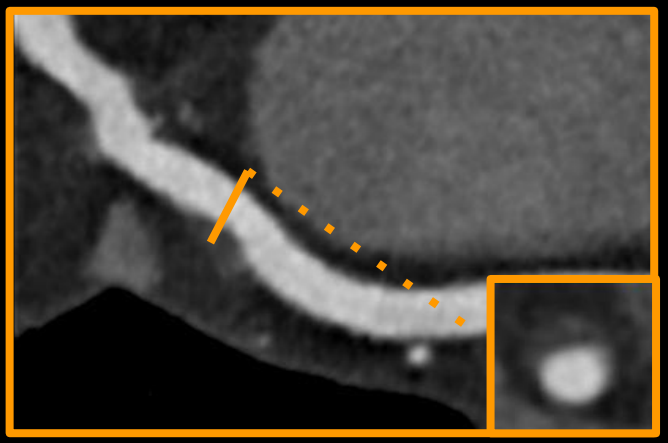


Low attenuation



Spotty cafcification

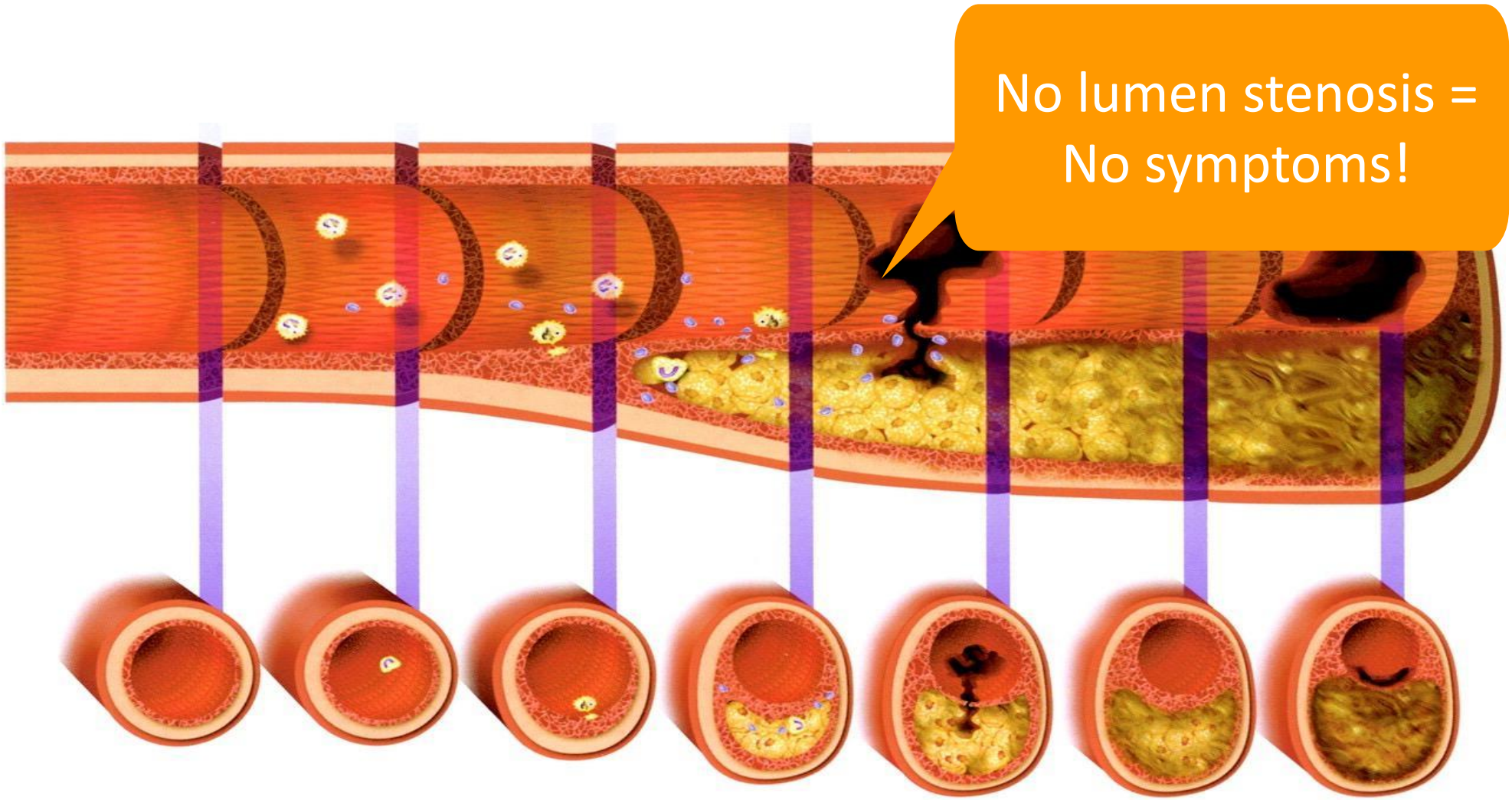
Napkin-ring sign



Positive remodelling

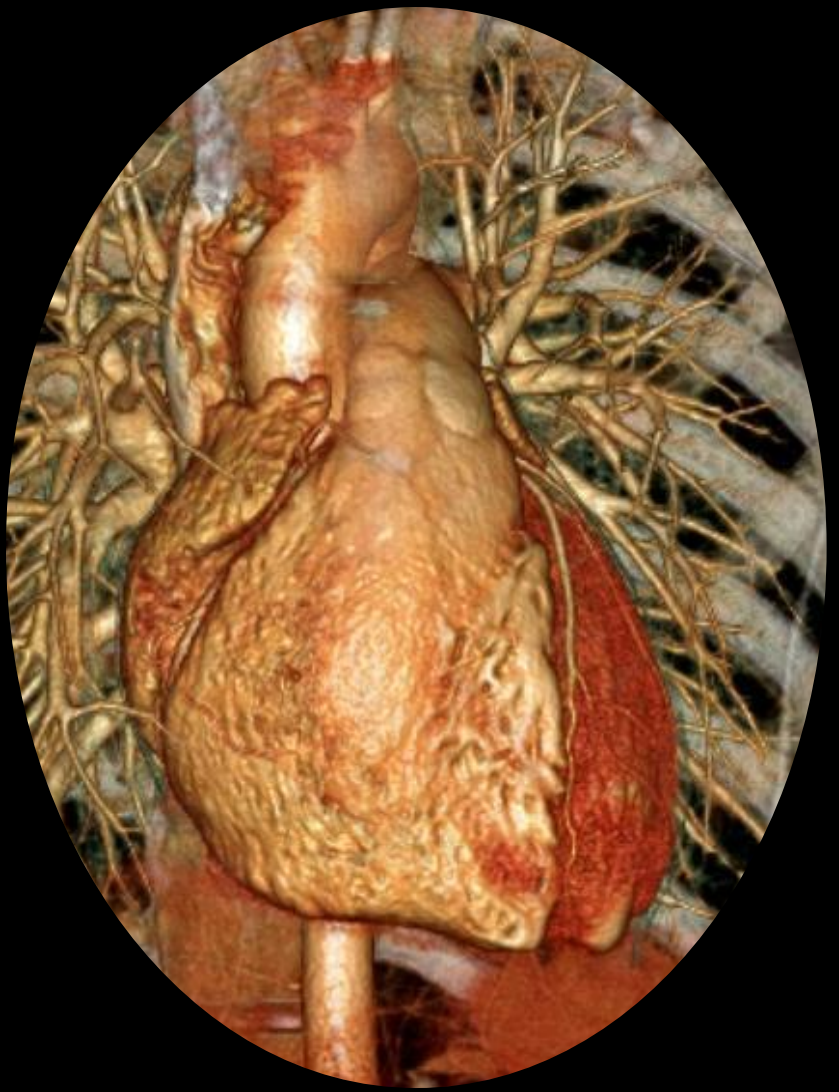
Maurovich-Horvat et al. Nature reviews 2014

Identification of asymptomatic vulnerable plaque (patient)

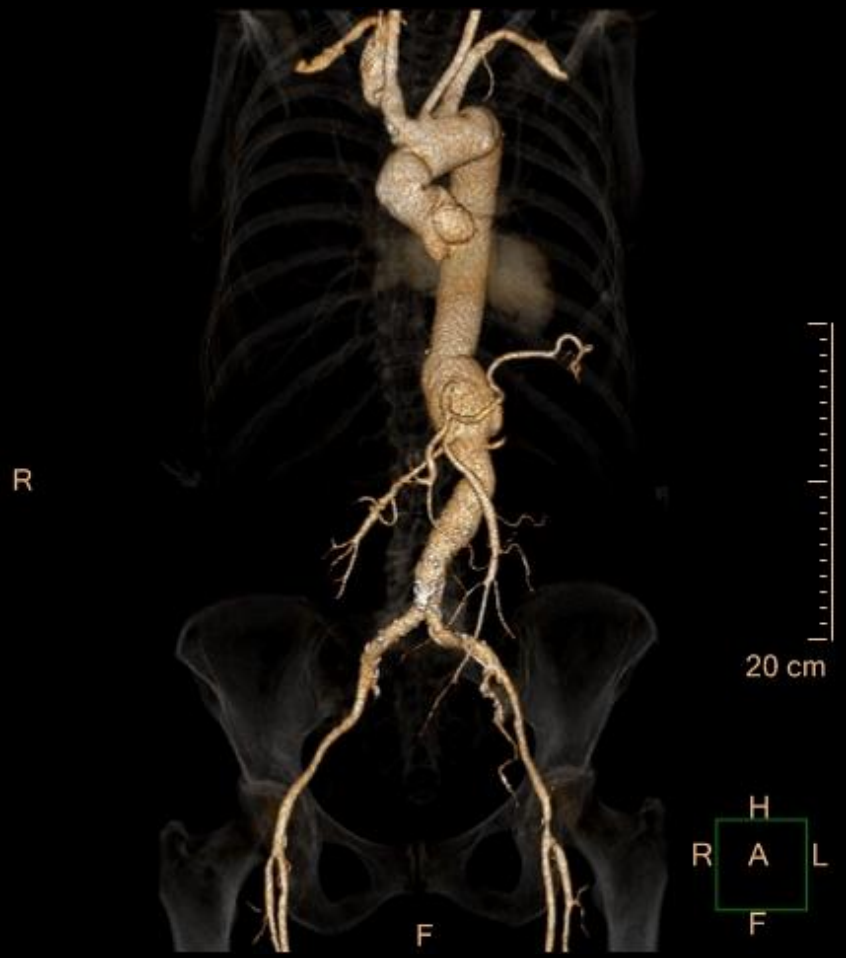


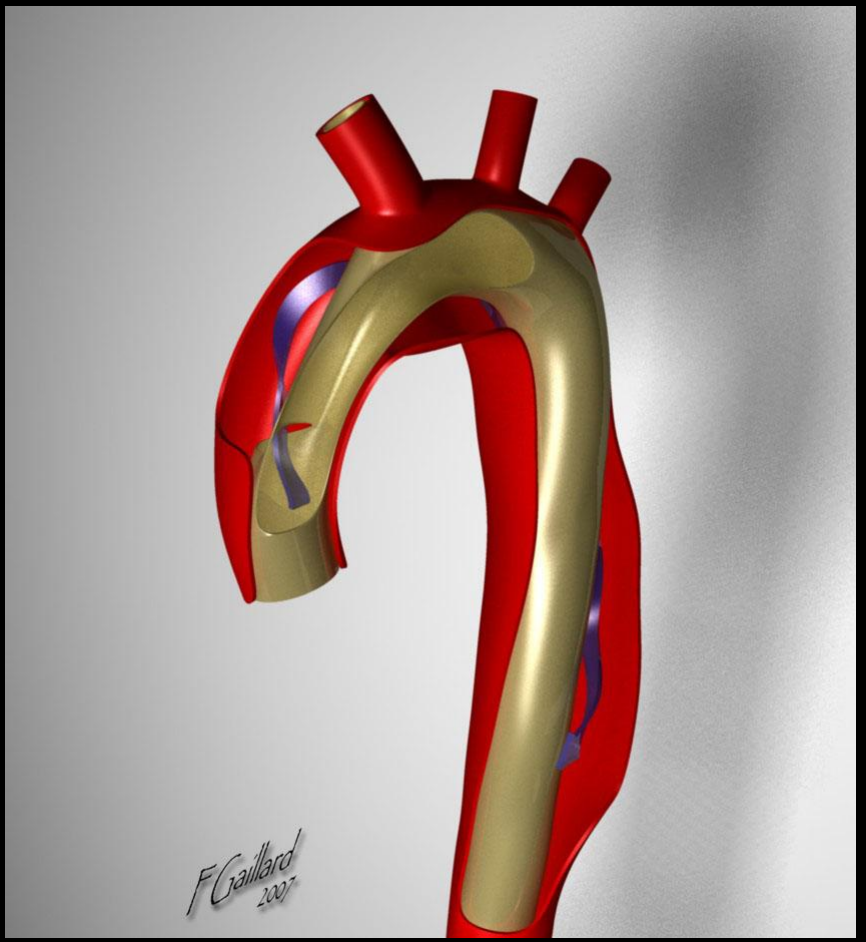
Take Home Message I.

The main indication of CCTA: Exclusion of coronary artery disease in case of chest pain with low/intermediate risk



II. Aortic CT angiography





Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 7640

Indications

- **Acute aortic syndrome**
  - **aortic dissection**
  - **intramural hematoma**
  - **aorta aneurysm rupture**
  - **penetrating atherosclerotic ulcer (PAU)**
  - **aortic injury (accident)**
- **Aorta thrombosis**
- **Follow up**

Imaging has to reach the level of femoral bifurcation to see the extent of the disease and to plan an endovascular treatment .

1. Aortic dissection

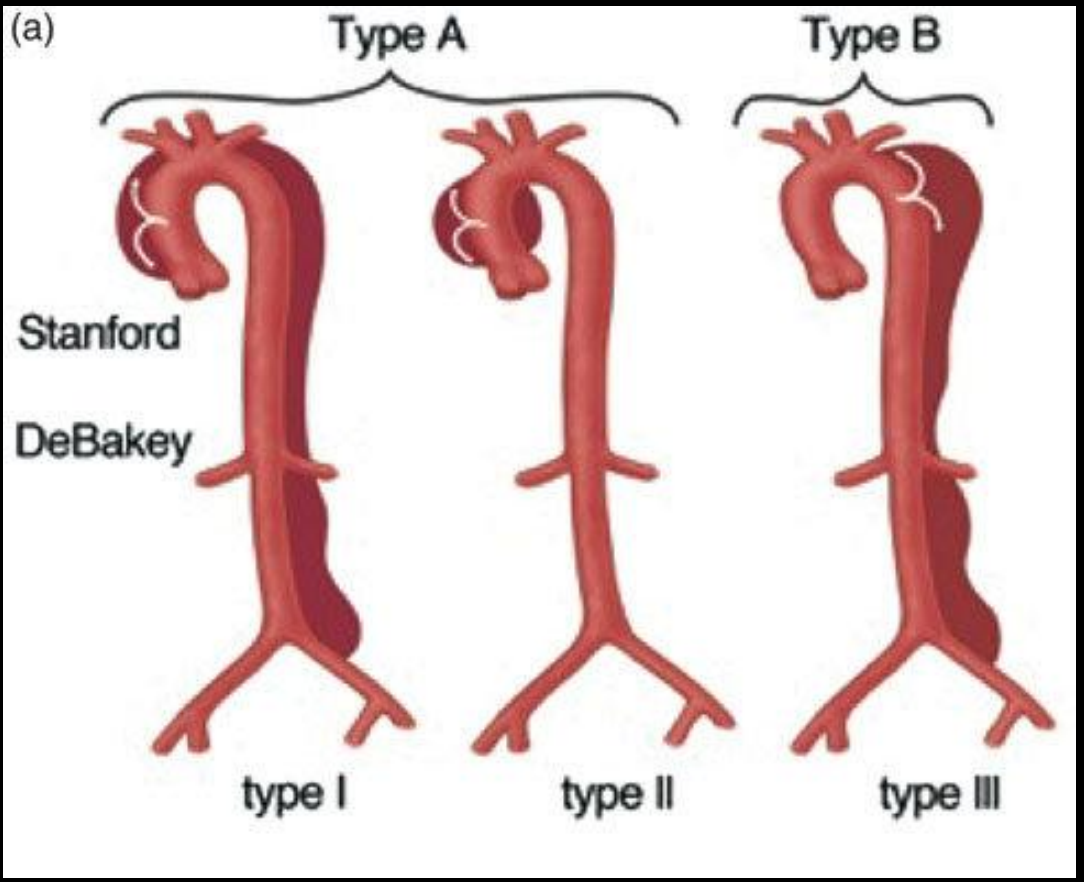
Stanford classification

- **Stanford A:**

Urgent cardiac surgery!

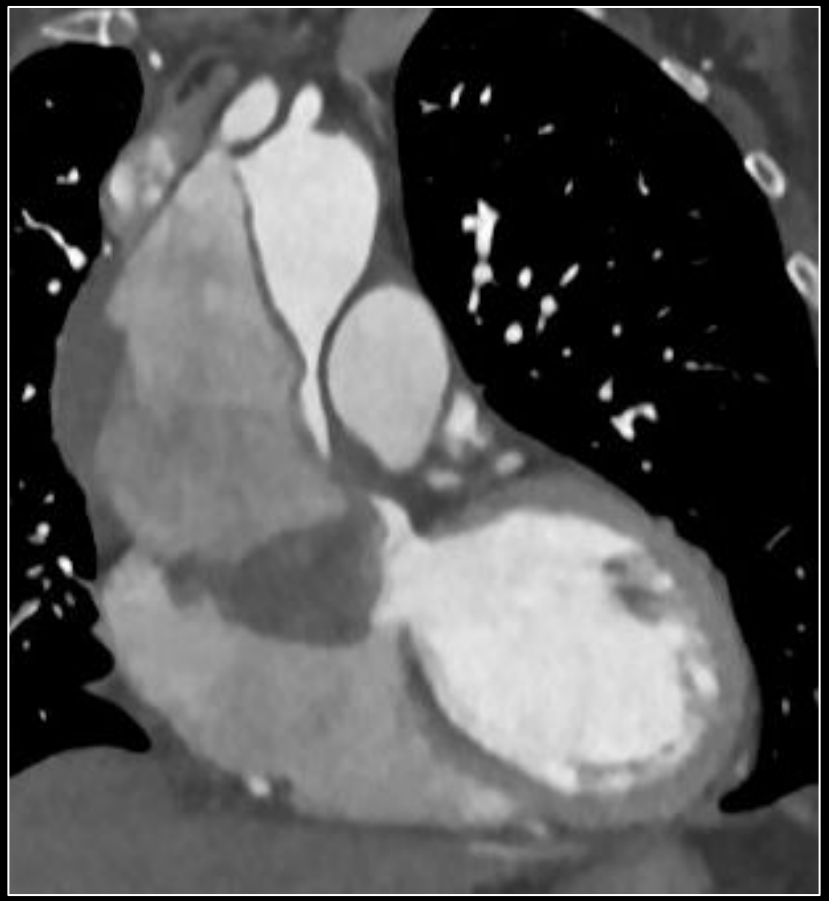
- **Stanford B:**

Conservative (medical treatment). Surgery or intervention in case of complication



Forrás:
https://www.researchgate.net/figure/a-Types-of-aortic-dissection-according-to-the-Stanf

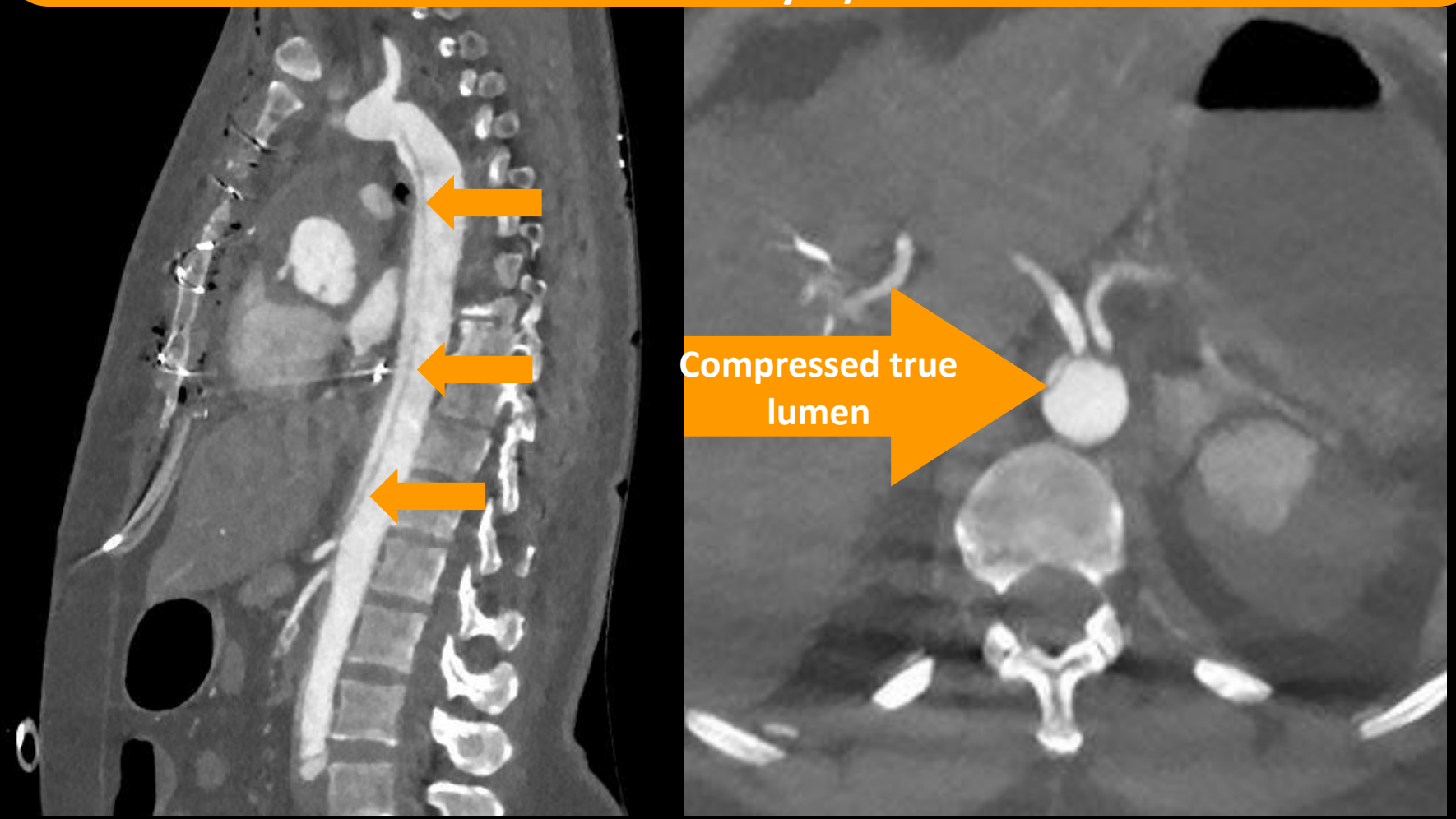
Stanford A dissection



Stanford B dissection

Case courtesy of Dr Yair Glick, Radiopaedia.org, rID: 73648

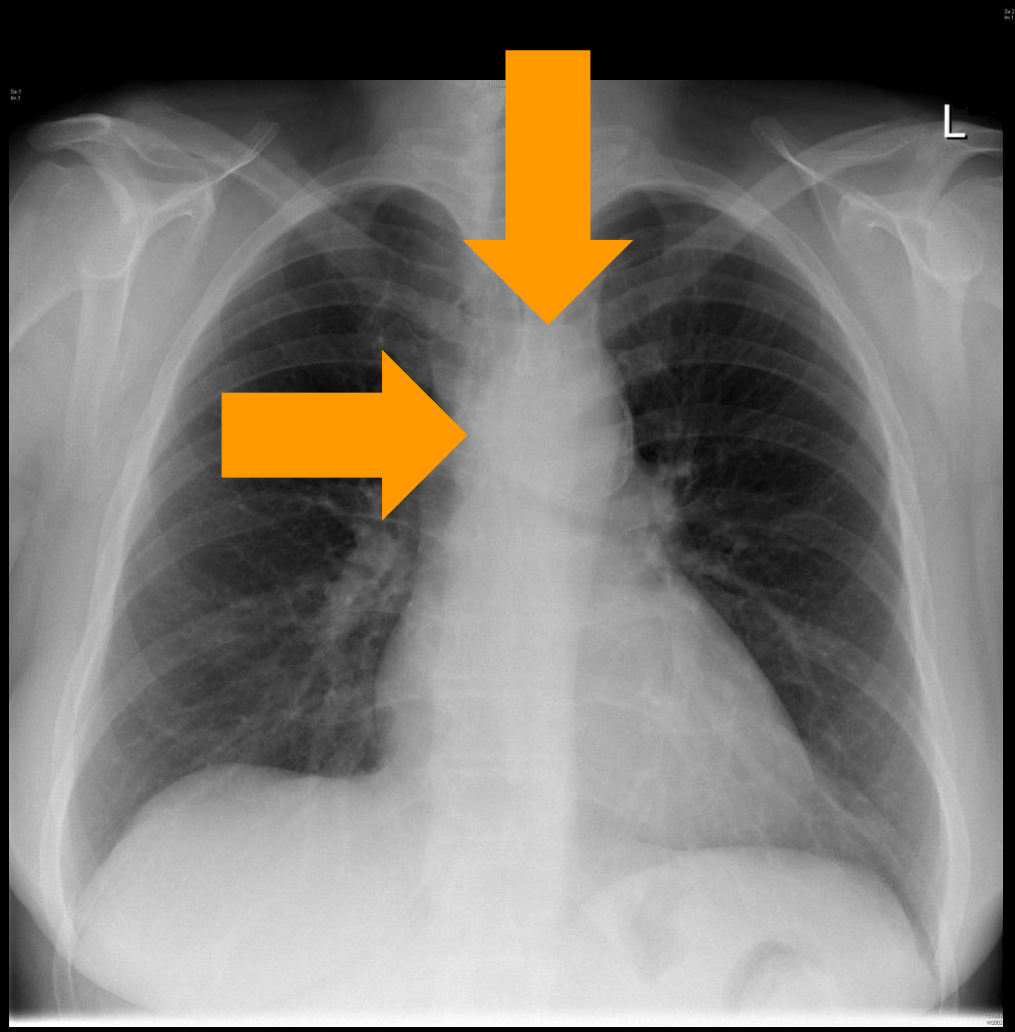
We must check supraoartic branches and thevisceral arteries (blood supply of bowels, kidneys)!

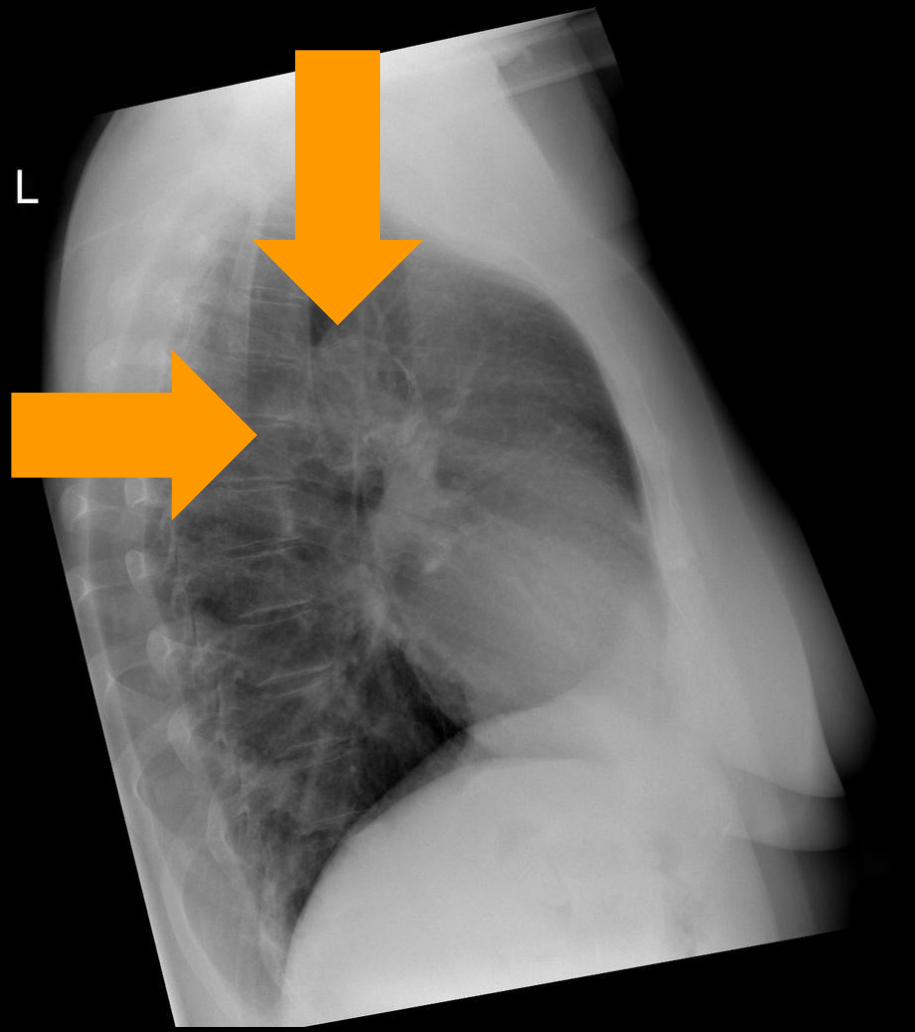


2. Aortic aneurysm

- Young adults:
  - Connective tissue disease (Marfan, Ehler-Danos syndrome)
  - The thoracic aorta is usually affected
  - Aortic root can be affected
  - After coarctation
  - Postdissectios aneurysm
- Adults (above 50 yo)
  - Typical patient: above 50 yo, smoking, hypertension, male
  - Infrarenal location is the most common
  - Iliac arteries and thoracic aorta can be affected

Thoracic aortic aneurysm



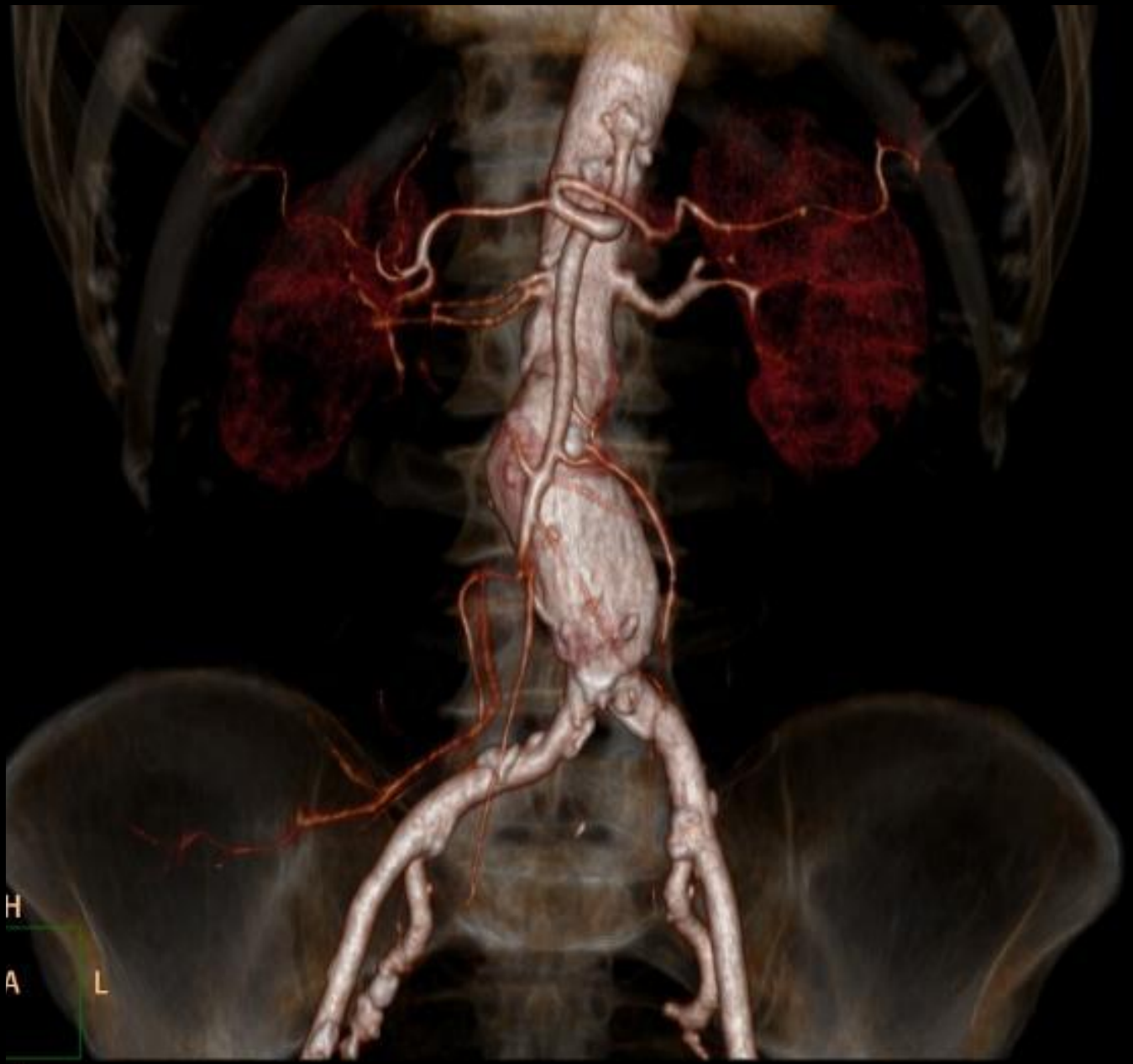


Case courtesy of Dr Nolan Walker, Radiopaedia.org, rID: 41586

Thoracic aortic aneurysm

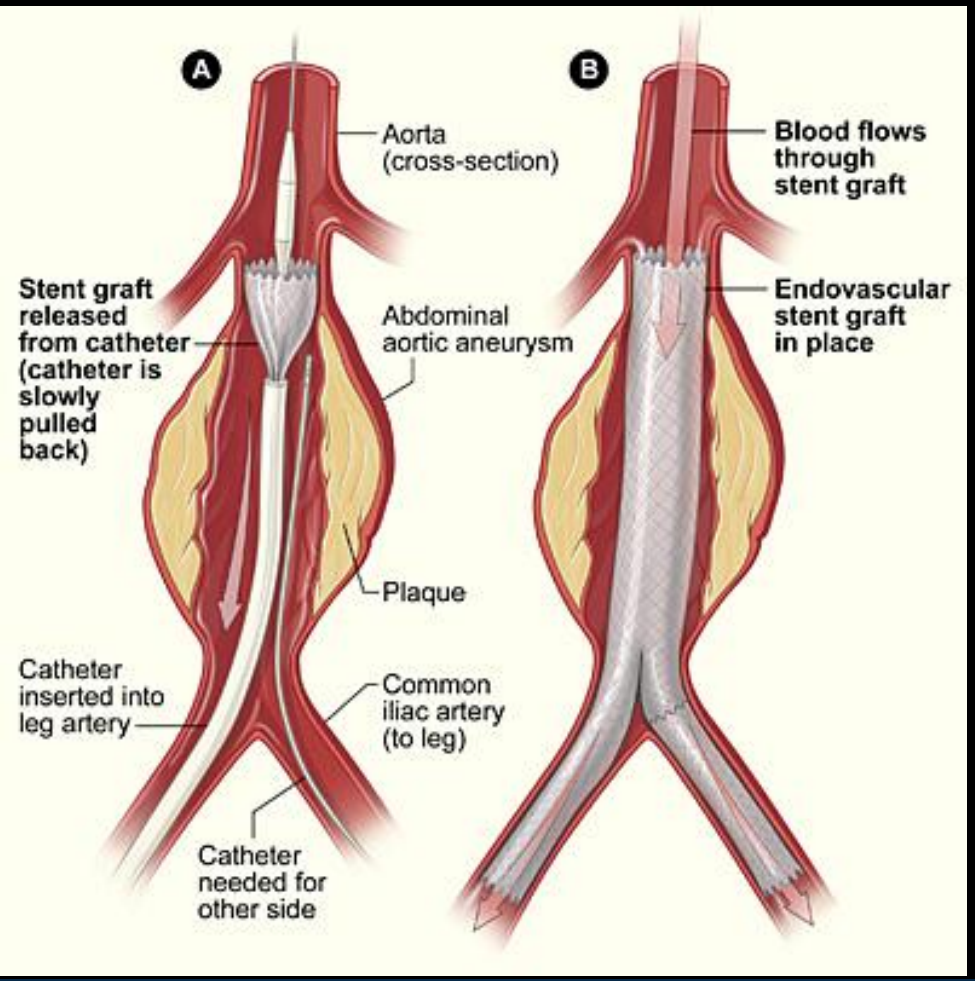
Case courtesy of Dr Nolan Walker, Radiopaedia.org, rID: 41586

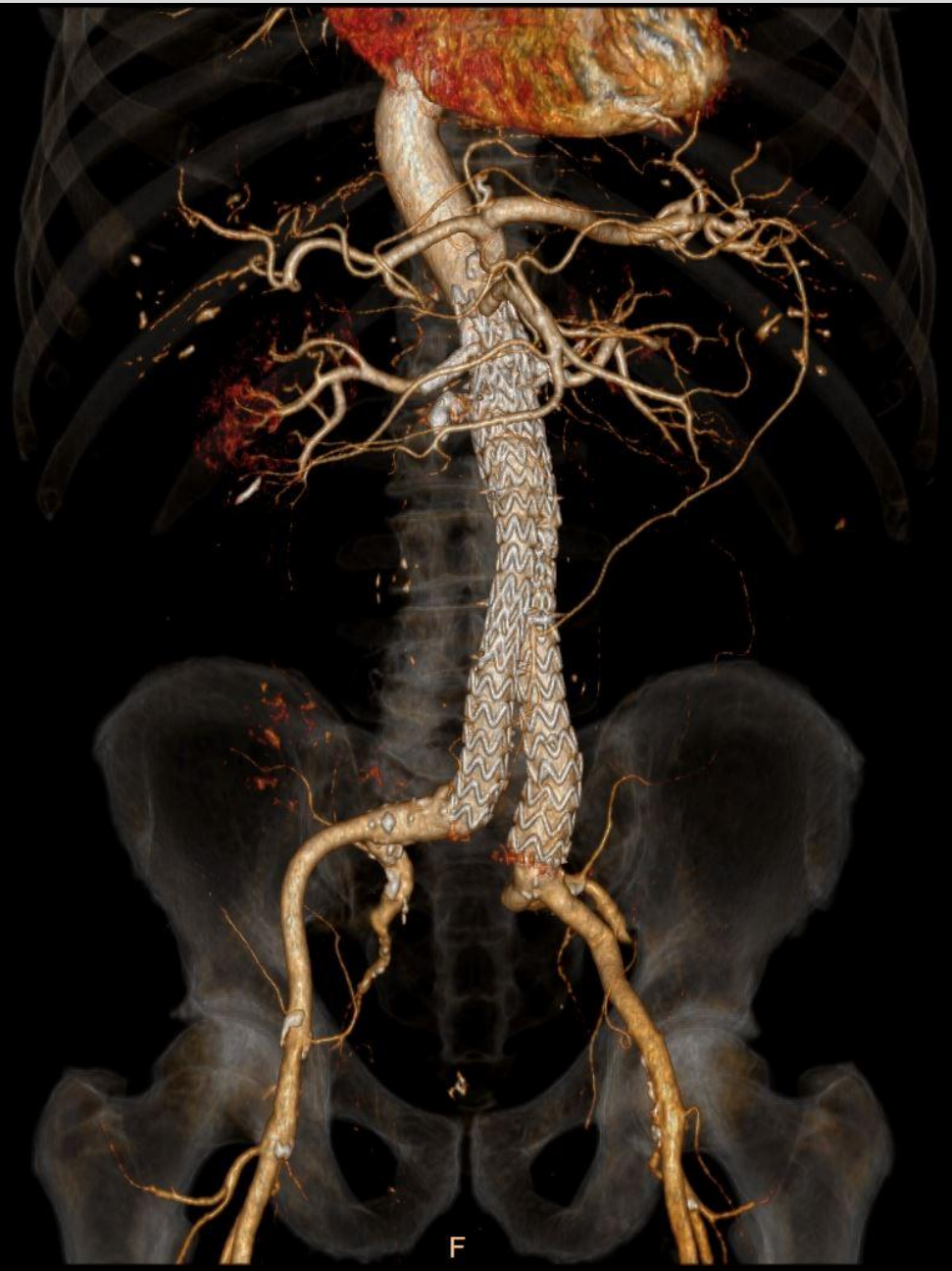
Abdominal aortic aneurysm



Case courtesy of Dr David Cuete, Radiopaedia.org, rID: 23703

After stent graft implantation

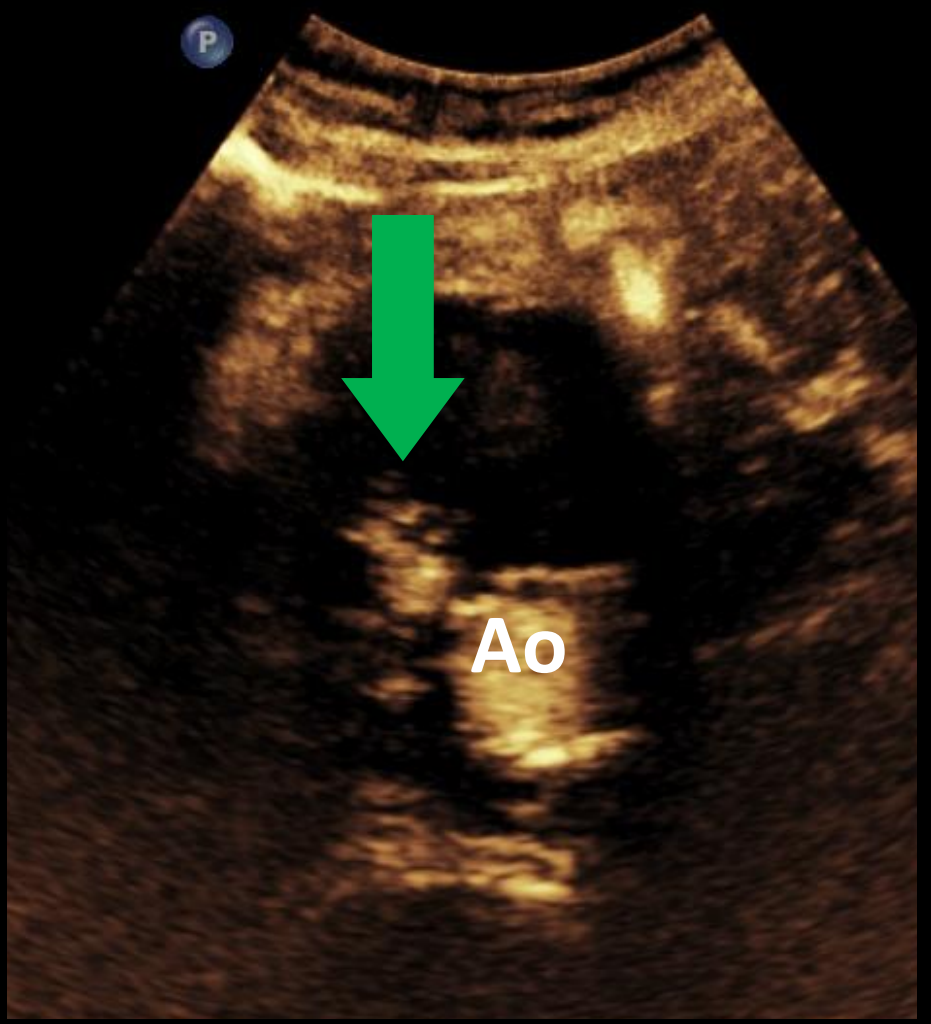




Endoleak detection

CT angiography

CEUS



3. Rupture

- Etiology

a) Dissection
   - Cardiac tamponade is the most common cause of death in patients with acute type A aortic dissection (AADA) before they present for medical care!

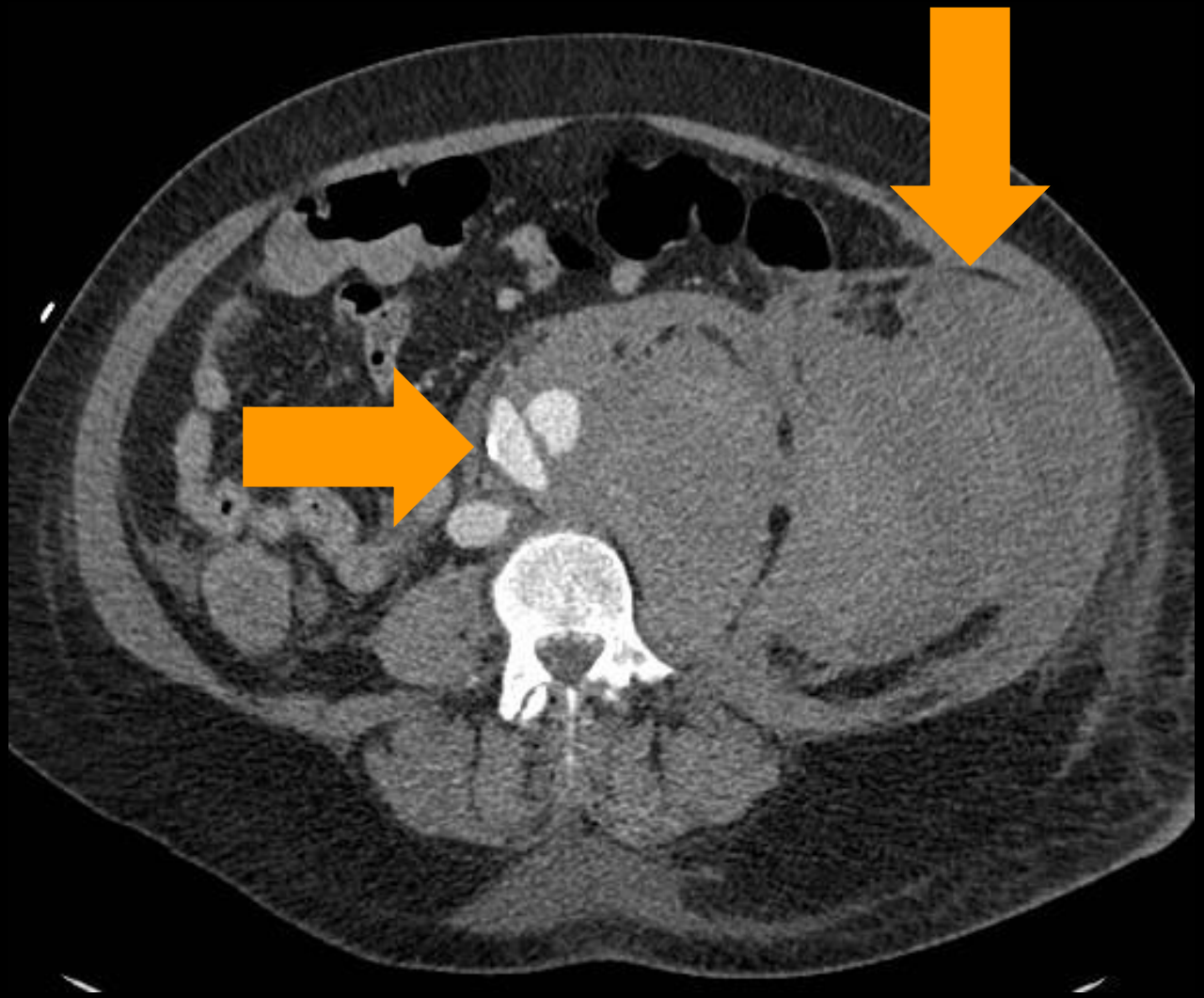
b) Aneurysm
   - Impending rupture: fast growth of the aneurysm >5 mm/6 months, diameter above 5 cm , inflammatory aortic aneurysm
   - Retroperitoneal bleed very common

c) Plaque rupture

d) Traumatic aortic rupture: isthmus is typically affected

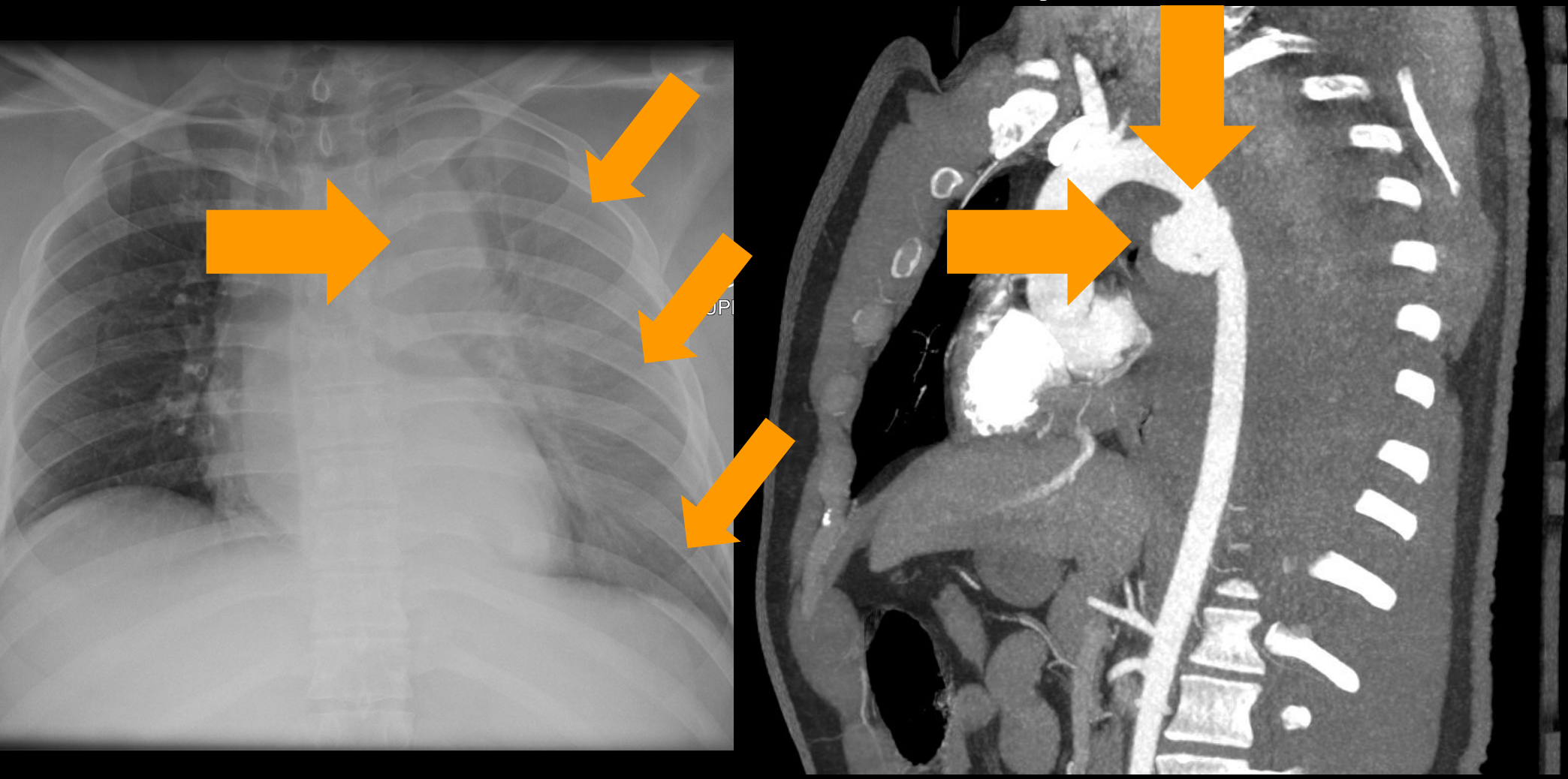
e) Iatrogenic (surgical complication)

Ruptured abdominal aneurysm



Case courtesy of Dr Ian Bickle, Radiopaedia.org, rID: 56831

Traumatic aortic rupture

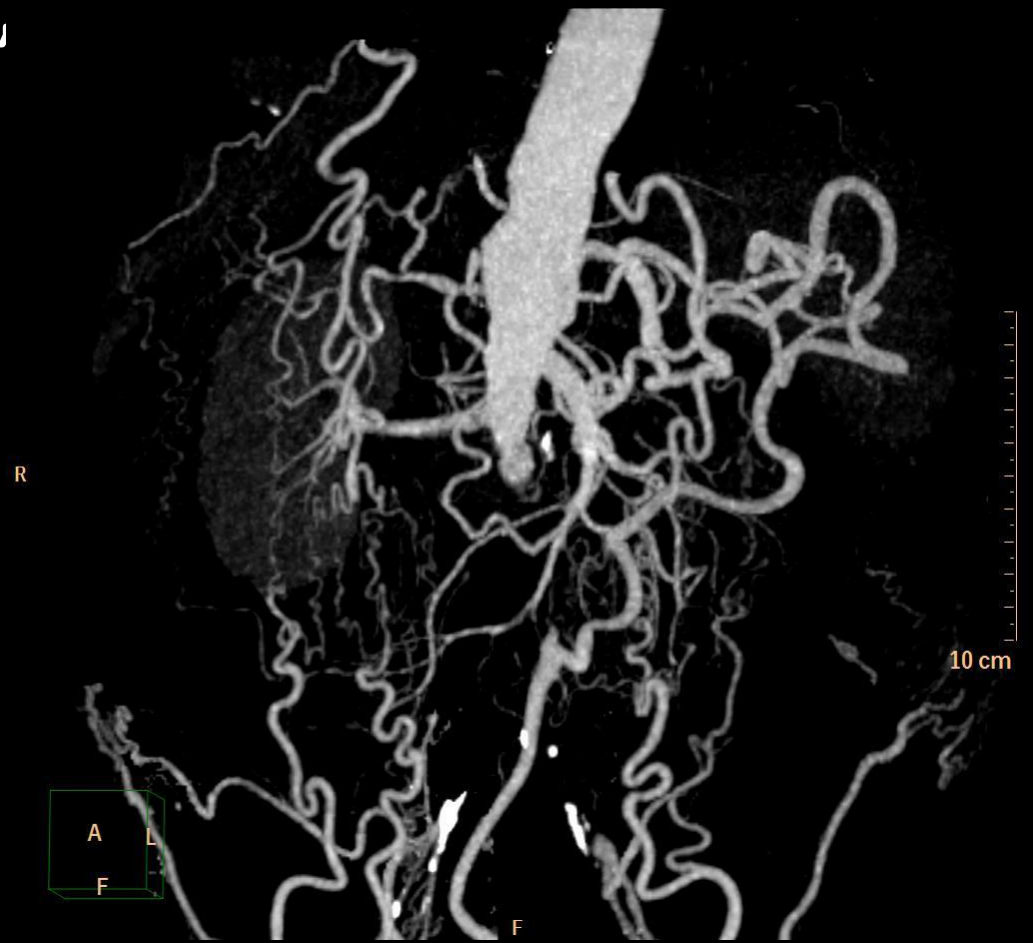


Case courtesy of Dr Andrew Dixon, Radiopaedia.org, rID: 45368

4. Aortic thrombosis

The classic presentation of limb ischemia is known as the „six Ps”

1. pain
2. pulselessness
3. pallor
4. paresthesia
5. paralysis
6. prostration



Case courtesy of Dr Dalia Ibrahim, Radiopaedia.org, rID: 31376

Technical aspects

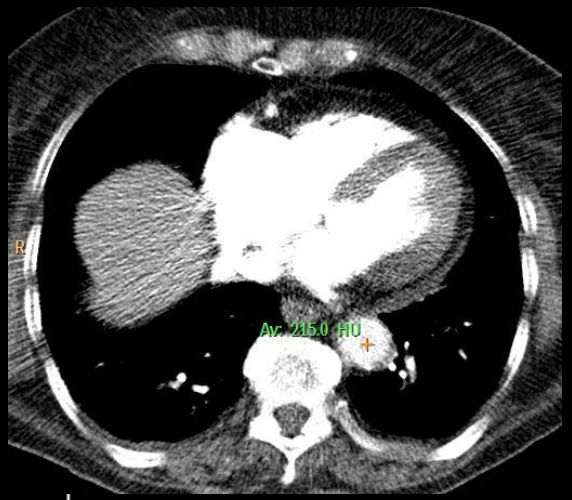
Which part of the aorta is affected?

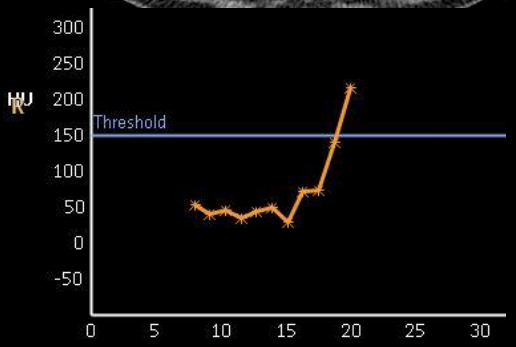
- **Dilatation of the ascending aorta**, dissection of the thoracic aorta
  - ECG synchronisation (prospective triggering).
- Dissection of the entire aorta, or thoracoabdominal aneurysm?
  - Retrospective ECG gating. (higher radiation dose)
- **Abdominal** aneurysm?
  - ECG synchronisation is not necessary.

ALARA pricinple!!!!

Imaging technique

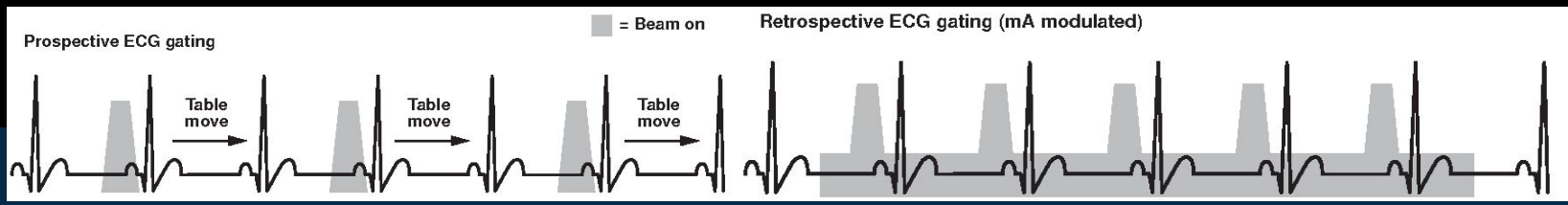
Bolus tracking



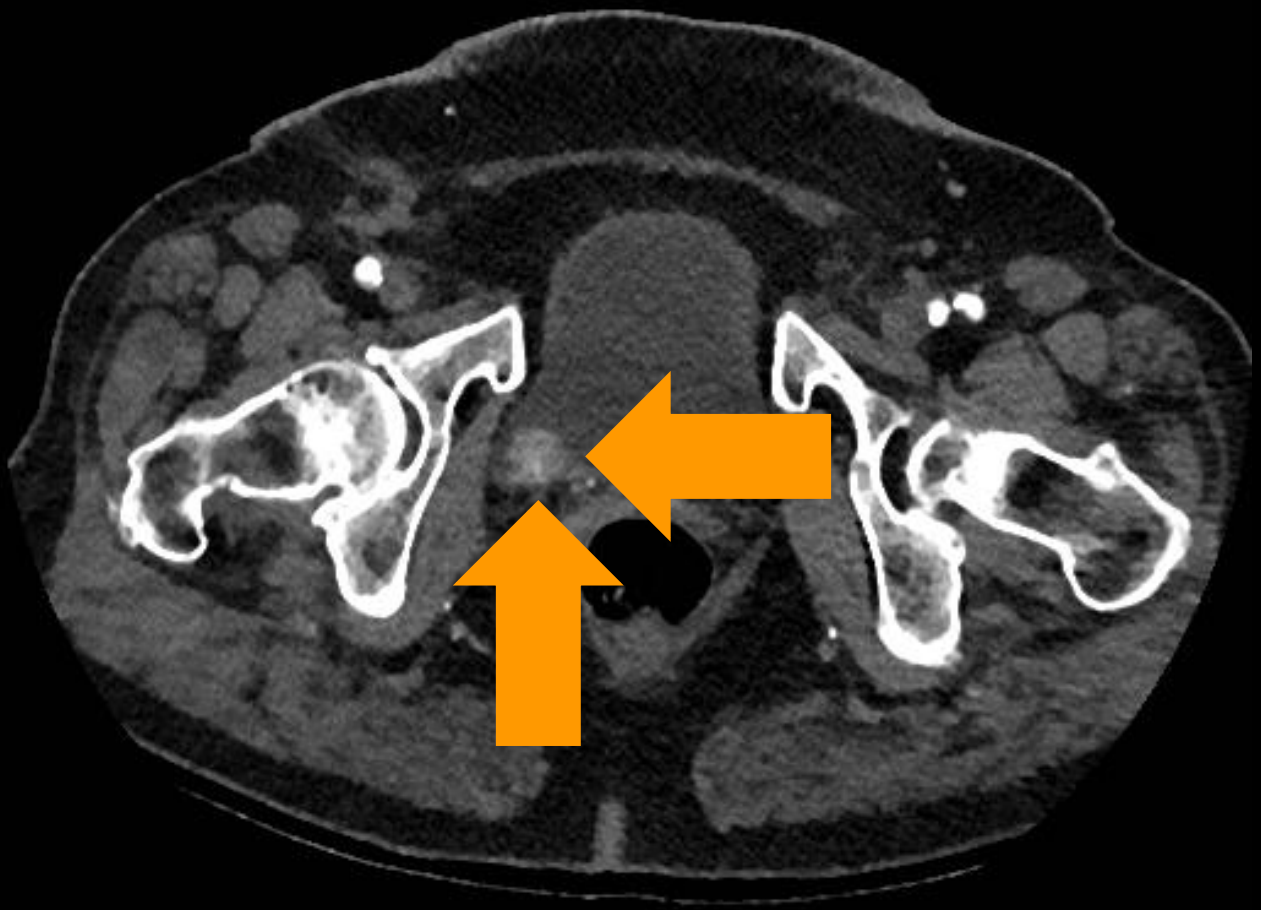


Step and shoot

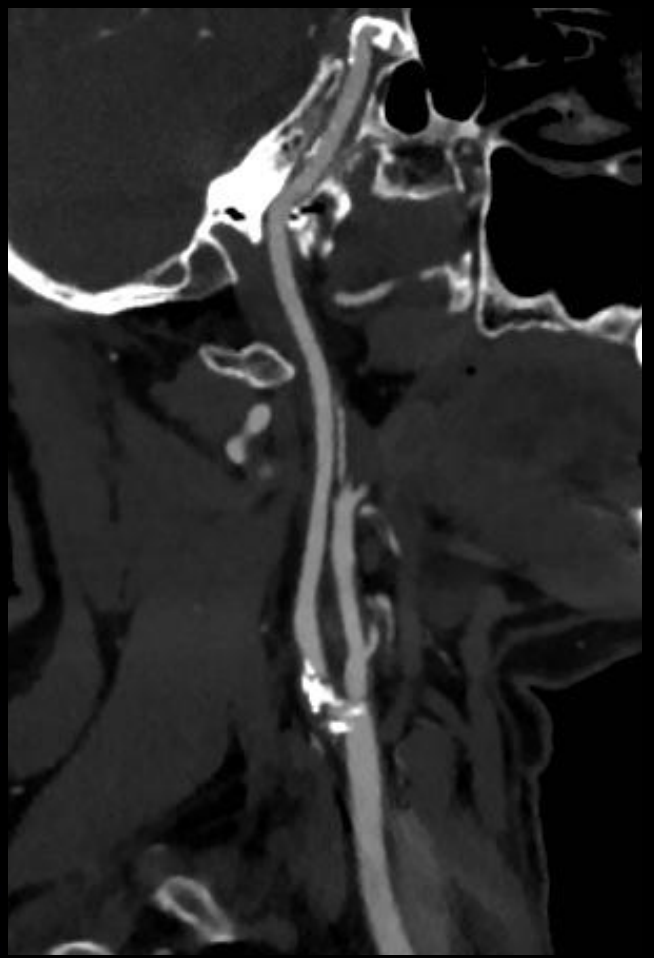
Helical



Incidental finding may be important!



III. Carotid CT angiography



Indication

- **Acute stroke, within time window**
- **Severe carotid stenosis**
- **Surgical/ intervention treatment planning**
- **Intracranial status assessment (aneurysm, stenosis)**
- **Rare: Subclavian steal**

Imaging technique

- Native head CT scan – is there any abnormal finding? Is it chronic or acute?

1. Negative

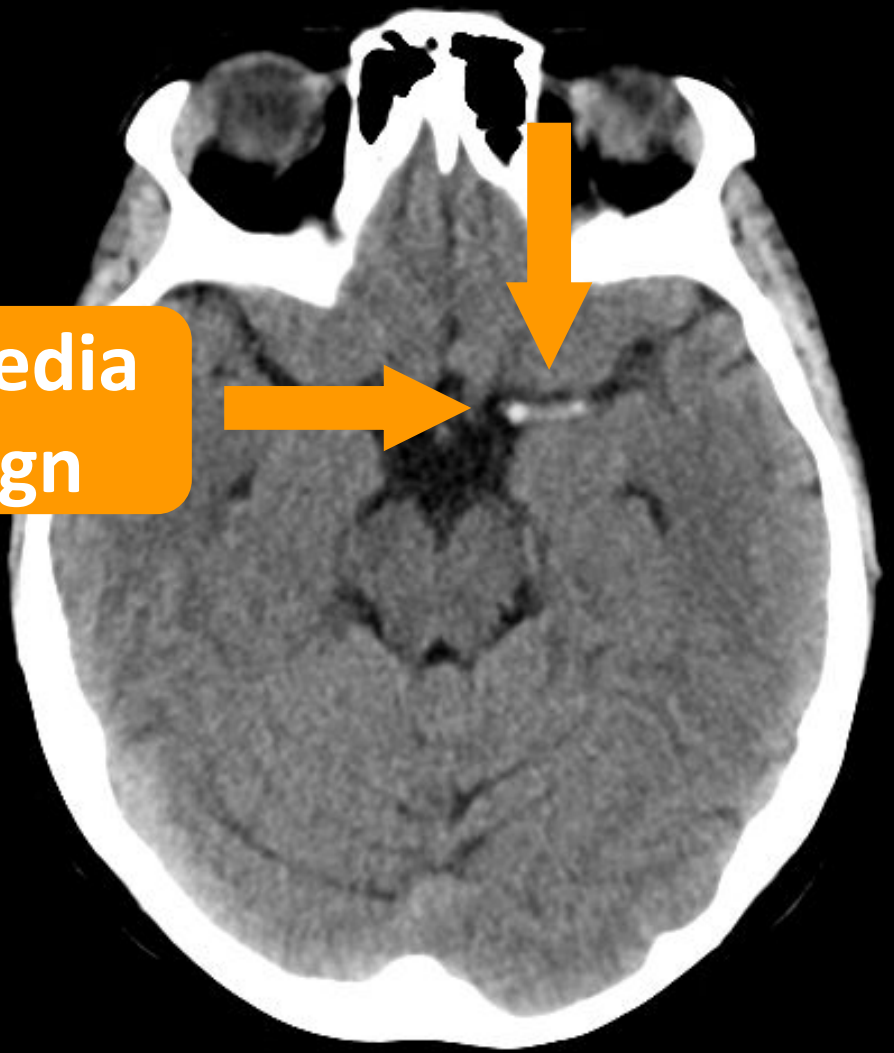
2. Previous stroke

3. Chr. hypoperfusio

Early Ischemic Changes

- Loss of insular ribbon (←)
- Loss of gray-white interface (◂)
- Loss of sulci (▾)
- Acute hypodensity
- Mass effect
- Dense MCA sign

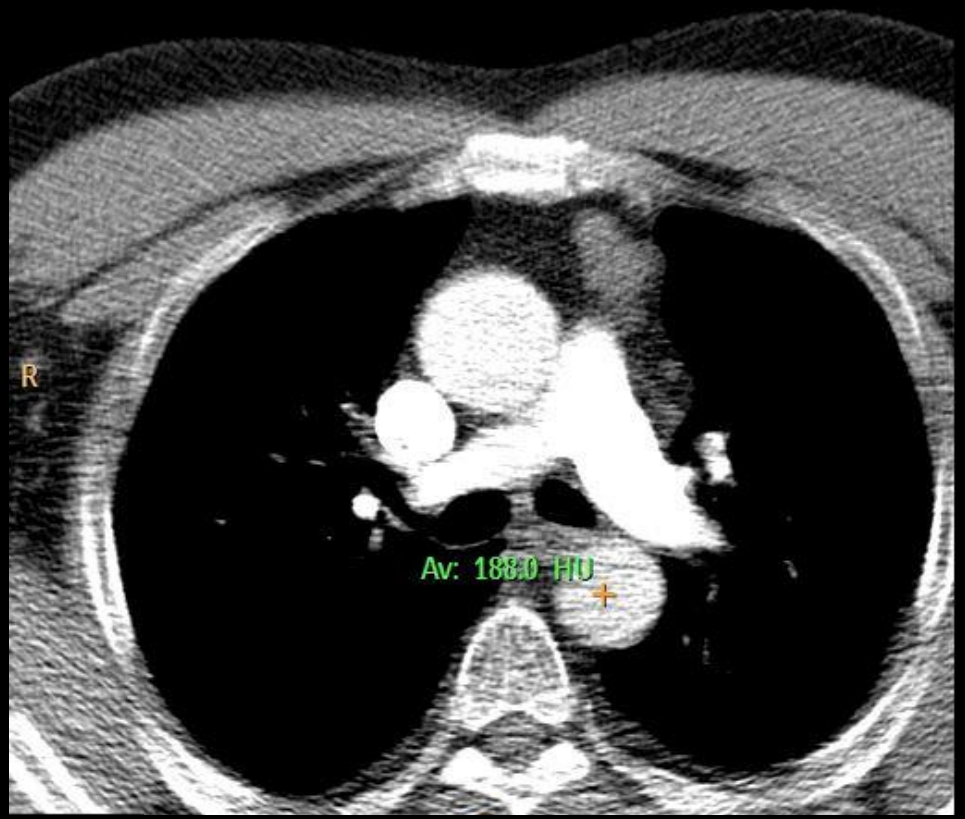
Acute stroke



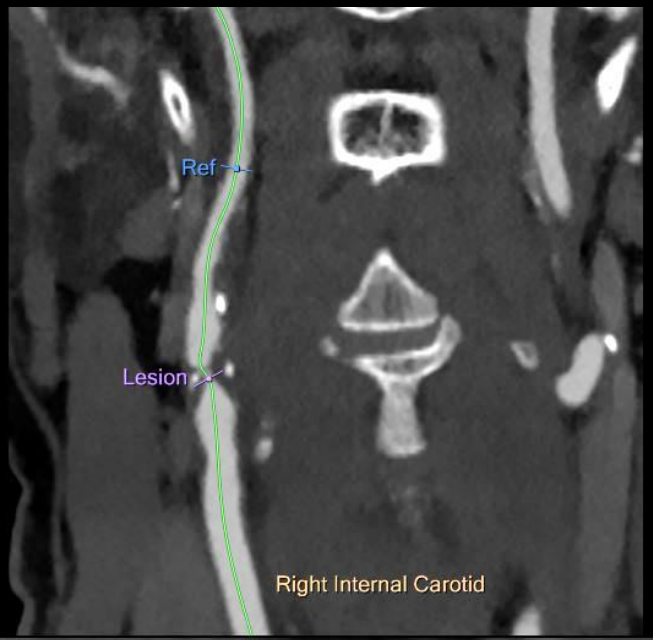
Hyperdens media sign, Gács sign

Case courtesy of Assoc Prof Craig Hacking, Radiopaedia.org, rID: 41870

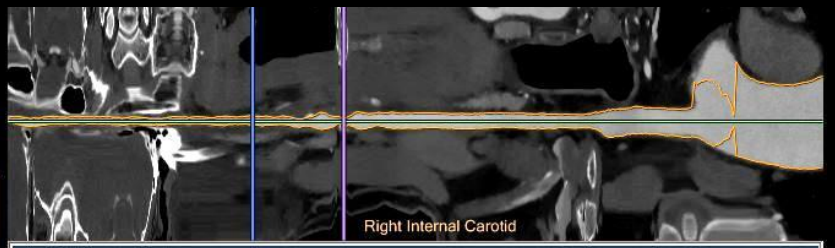
Bolus tracking from the aortic arch/ descending aorta



Evaluation of carotid stenoses

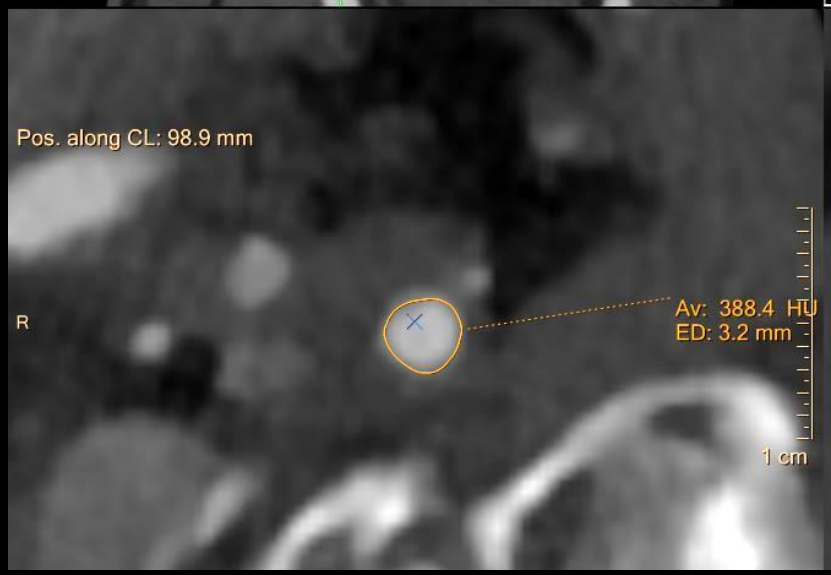


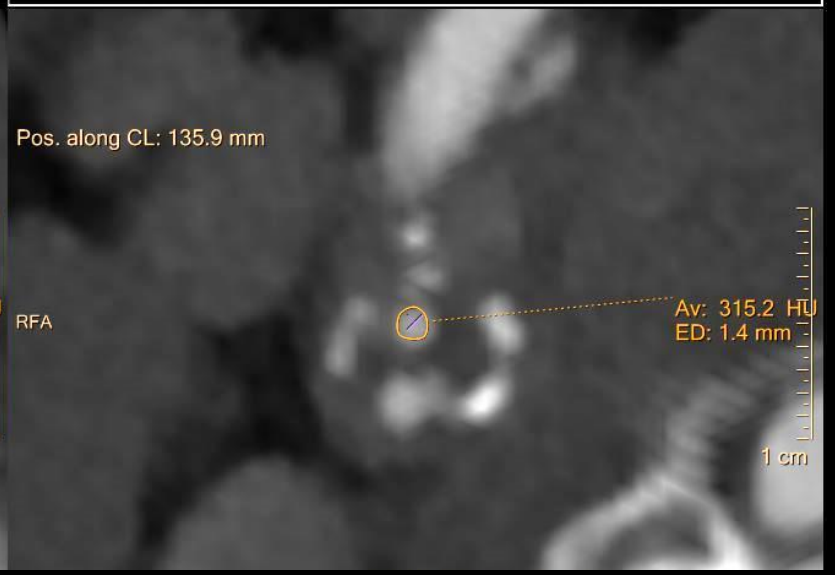
R



5 cm

Lumen Measurements - Right Internal Carotid			
	Reference	Lesion	Difference
Maximum Diameter	3.4 mm	1.4 mm	57.4 %
Minimum Diameter	3.2 mm	1.3 mm	58.9 %
Eccentricity	0.1	0.1	54.6 %
Effective Diameter	3.2 mm	1.4 mm	58 %
Area	8.3 mm^2	1.5 mm^2	82.4 %
Position	98.9 mm	135.9 mm	37 mm
Tortuosity	--	--	1.1





Who needs surgery?

- According to the North American Symptomatic Carotid Endarterectomy Trial (NASCET):

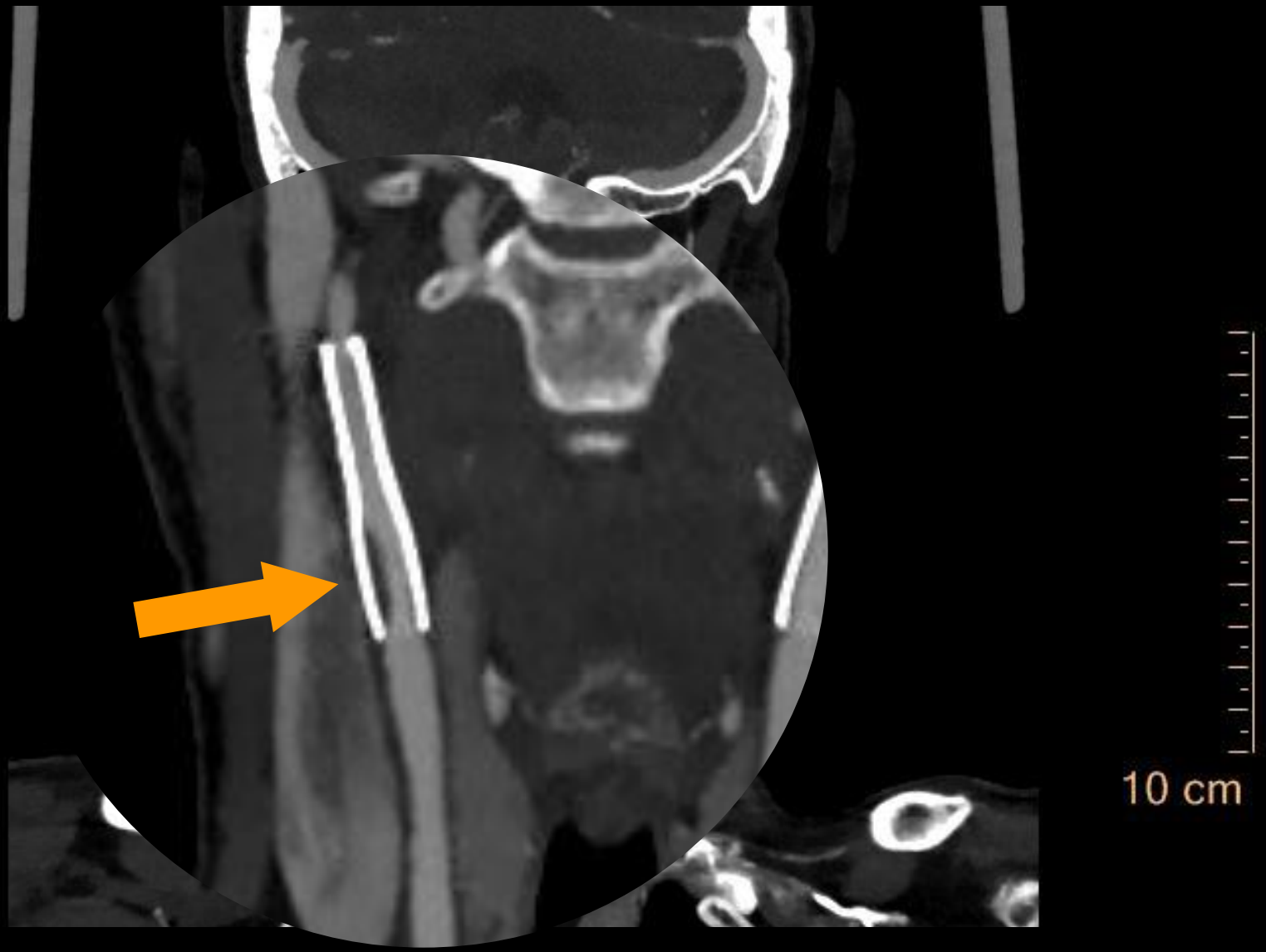
% ICA stenosis = (1 - [narrowest ICA diameter/diameter normal distal cervical ICA]) x 100

- Evaluation of the carotid stenosis:

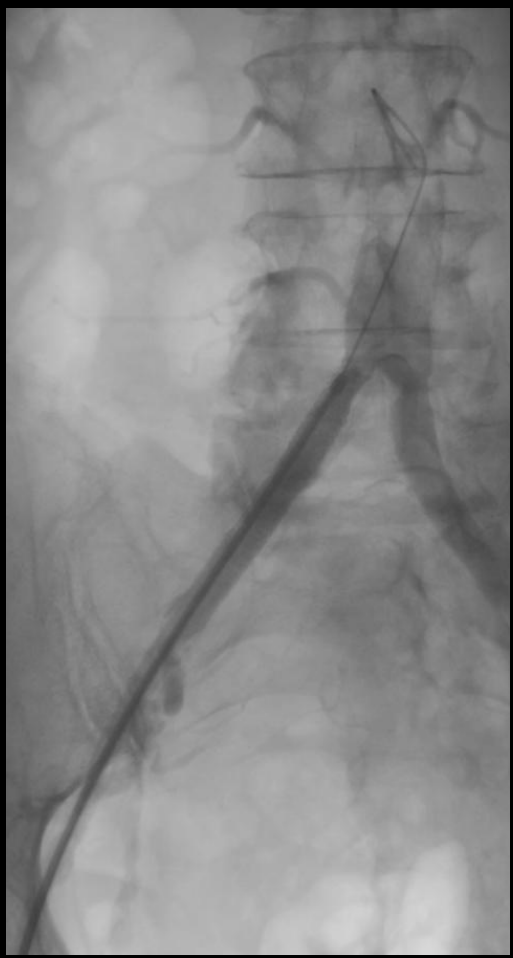
- mild: < 50%
- moderate: 50-70%
- severe: > 70%
- critical / preocclusive: > 90%

- Surgical indication:
  - Asymptomatic patient stenosis above 70-80%
  - Symptomatic patient 50-69% (TIA, vision loss)

Follow up of carotid stent impl.



IV. Lower limb CT angiography



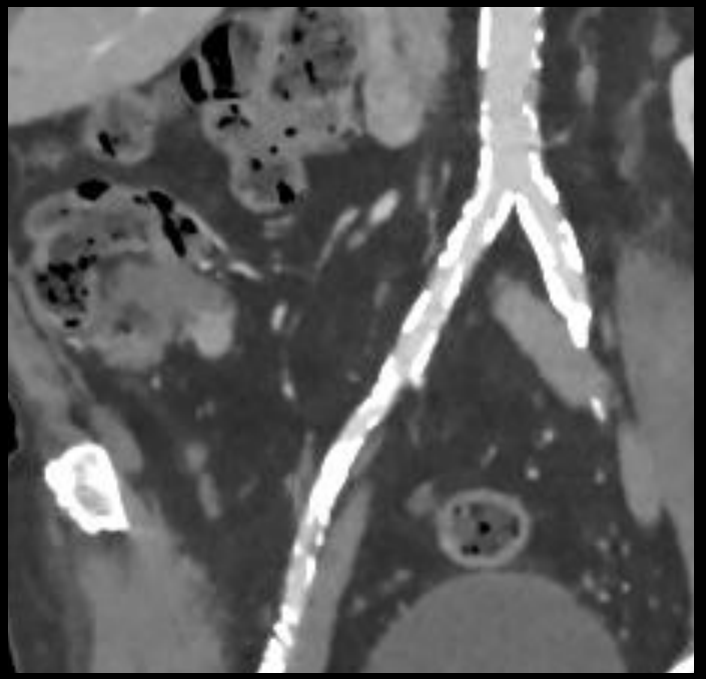
Indication

- **LE claudication**
- **Critical lower limb ischaemia**
- **Acute embolisation – source of embolism (aneurysm, intracardial thrombus)**
- **Surgery / interventional treatment planning**
- **Detection of complication**

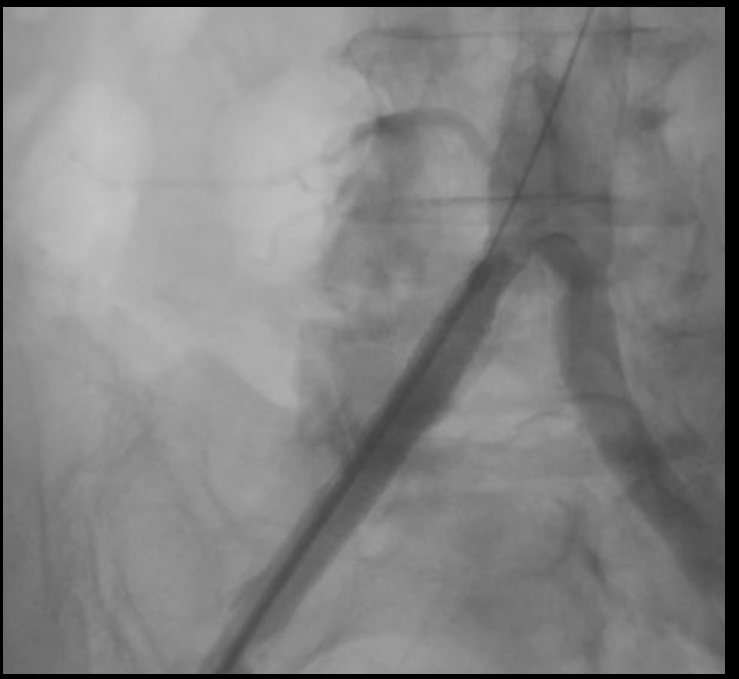
Technical aspects

- **Bolus tracker in the abdominal aorta**
- **Long contrast bolus (high amount of contrast media)**

CTA vs. DSA



- Non-invasive
- Lower spatial and temporal resolution
- Severe calcifcation - poor image quality
- Assessment of crural arteries difficult
- Intravenous contrast material
- Intervention not possible



- Invasive
- Good spatial and temporal res.
- Better IQ with calcified vessels
- Assessment of crural arteries better
- Intraarterial contrast material
- Intervention possible

Lower limb art. stenosis - image reconstructions

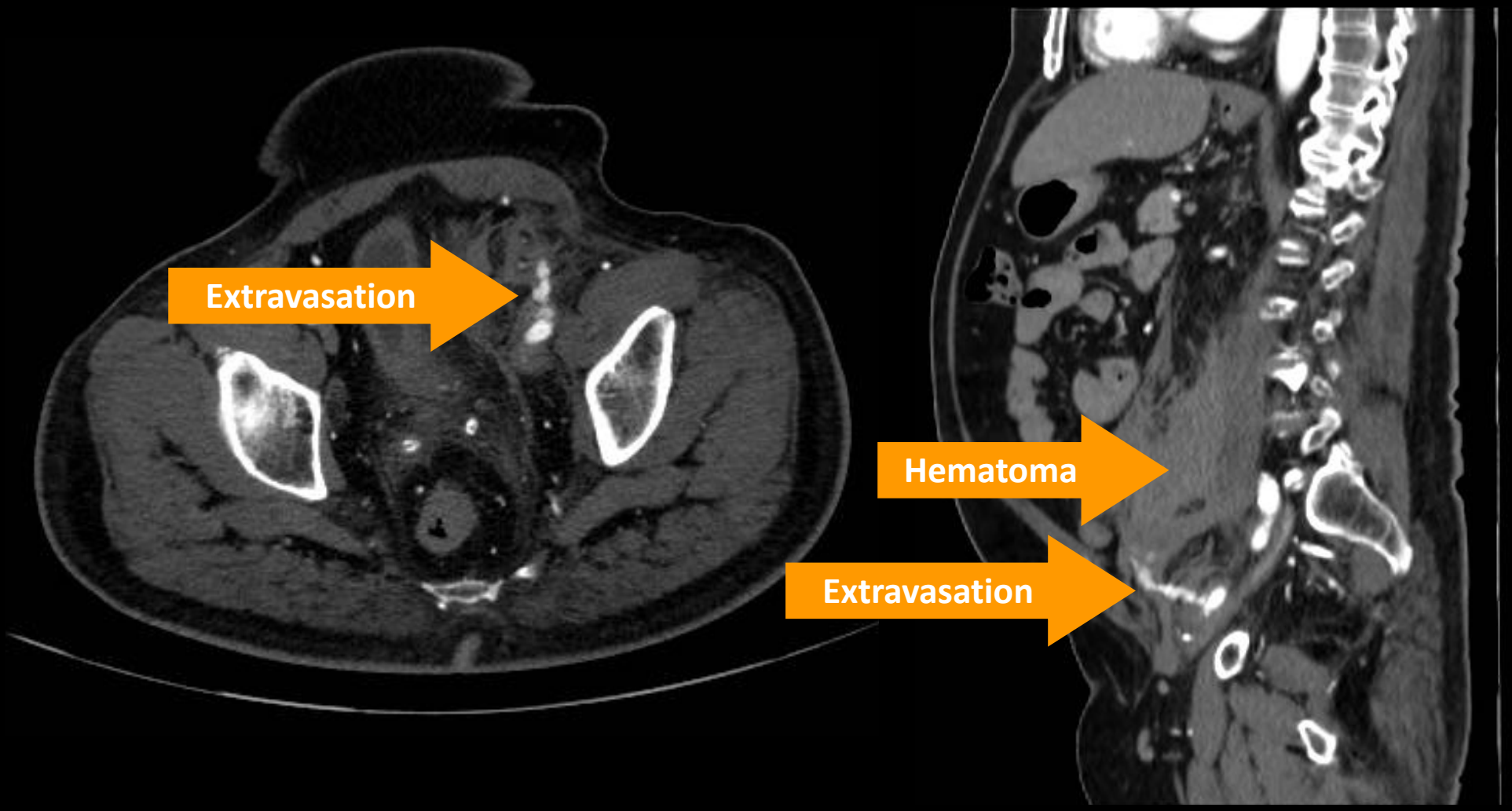
1. Volume

2. MIP

3. „Curved”

Severe calcification – the assessment of the lumen might be very difficult

Complication of the intervention: retroperitoneal hematoma



V. Pulmonary CT angiography

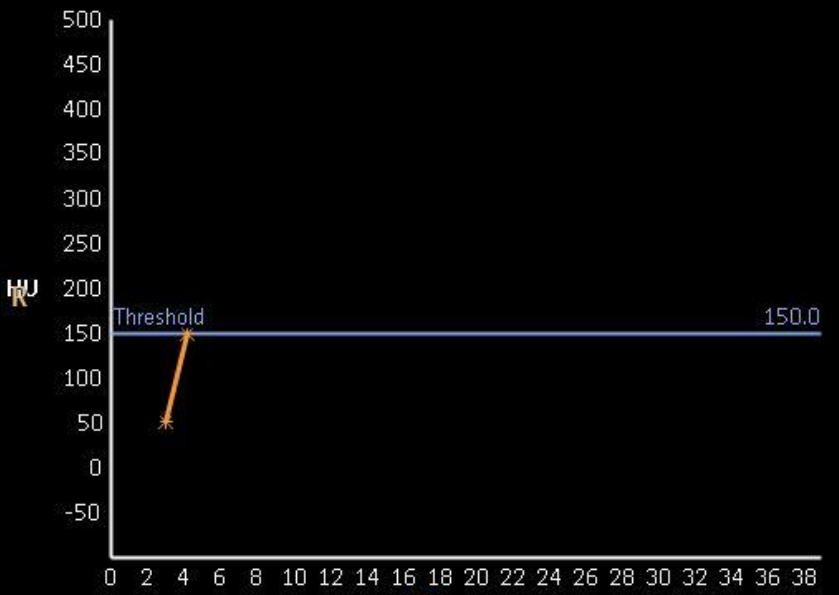
Indication

- **Symptoms of acute pulmonary embolism :**
  - **Dyspnea**
  - **Cyanosis**
  - **Right ventricular overload (ECG, echocardiography)**
  - **Deep vein thrombosis**
  - **Elevated D-dimer (sensitive, but not specific!)**

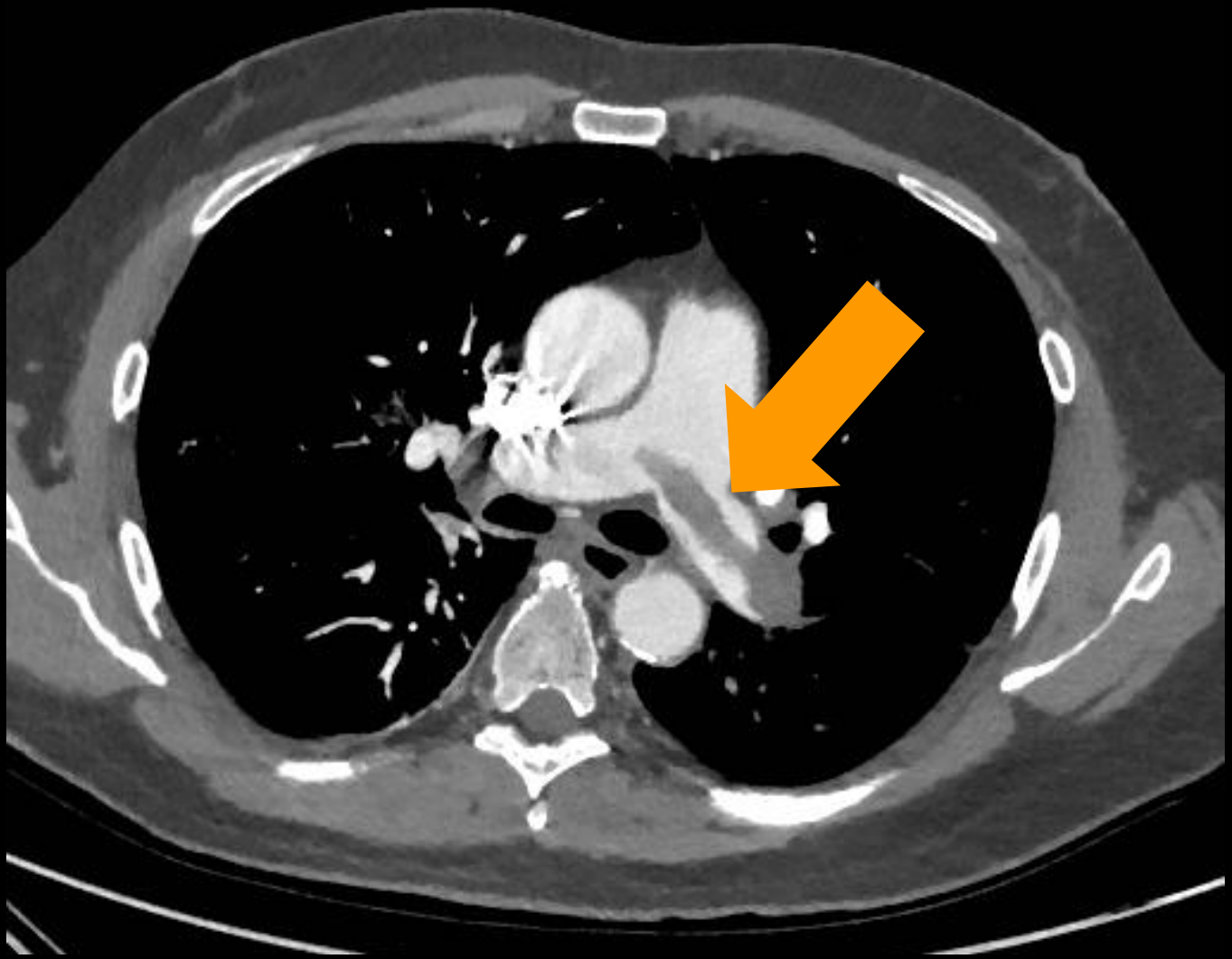
- **Pulmonary hypertension caused by chronic pulmonary embolism**

Imaging technique

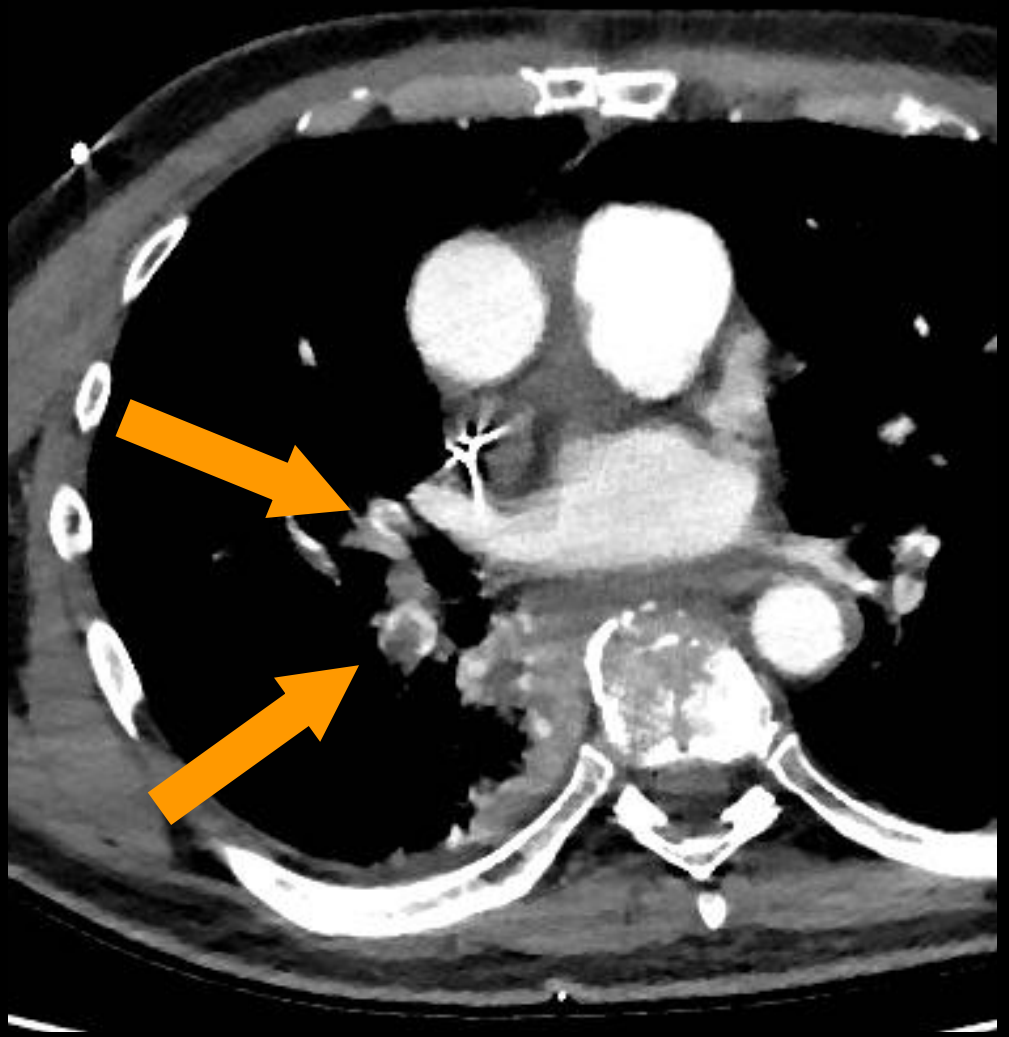
- **Native chest CT**
  - **Evaluation of lung parenchyma. Other pulmonary pathology (pneumonia, PTX, tumor, fibrosis?**
- **Pulmonary CT angiography**
  - **Bolus tracker in the right ventricle**



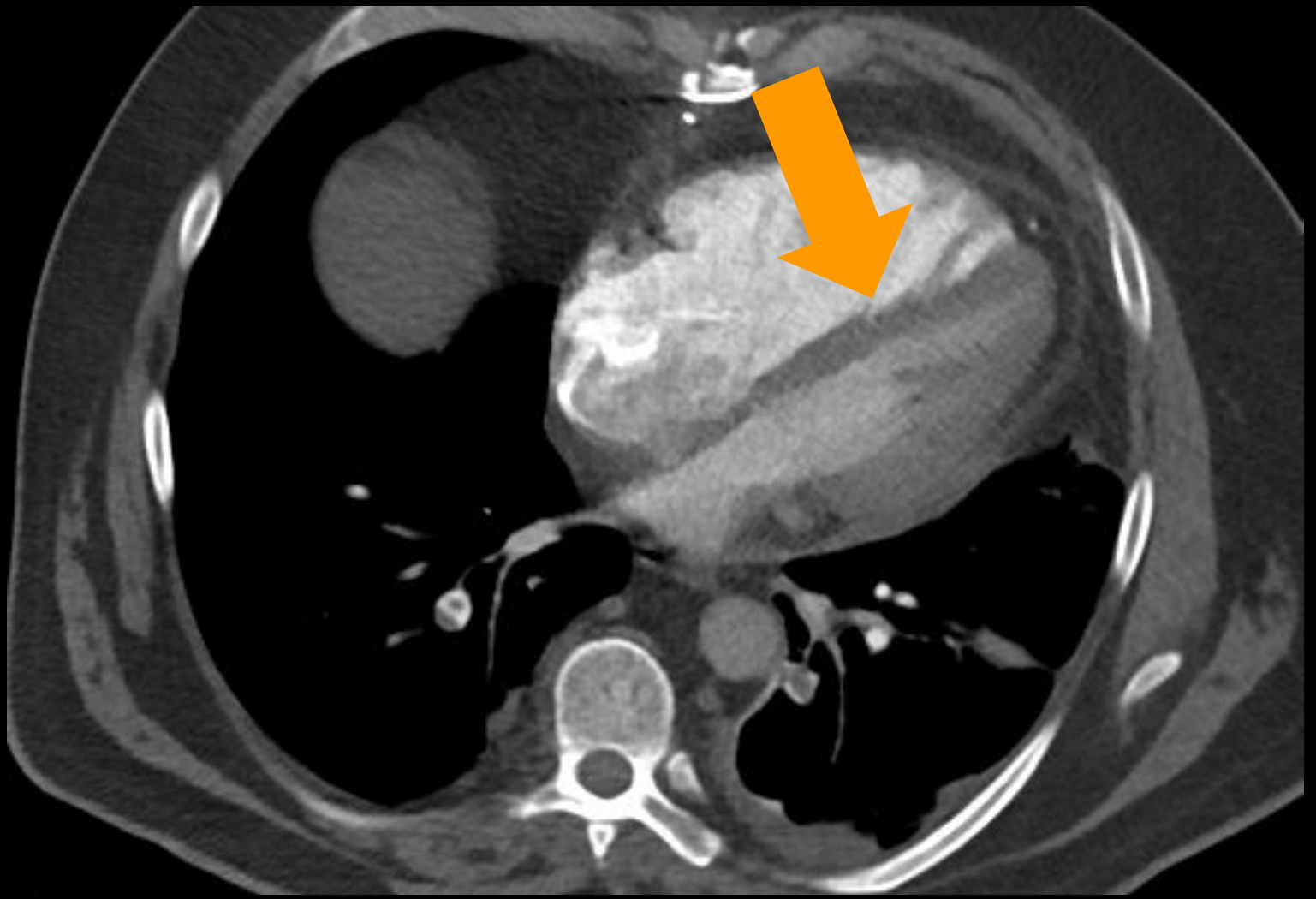
Saddle pulmonary embolism



Pulmonary embolism with pulmonary infarction



Signs of right ventricular overload



Case courtesy of Assoc Prof Craig Hacking, Radiopaedia.org, rID: 35799

Student research

Performance of non-contrast MRA in the diagnostics of peripheral artery disease

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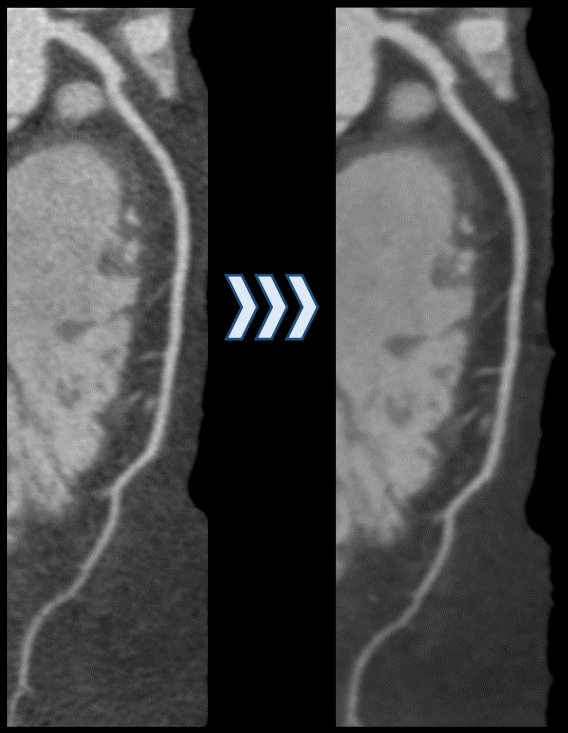
Student research

Performance of non-contrast MRA in the diagnostics of peripheral artery disease

Image quality assessment of a new generational cardiac-CT



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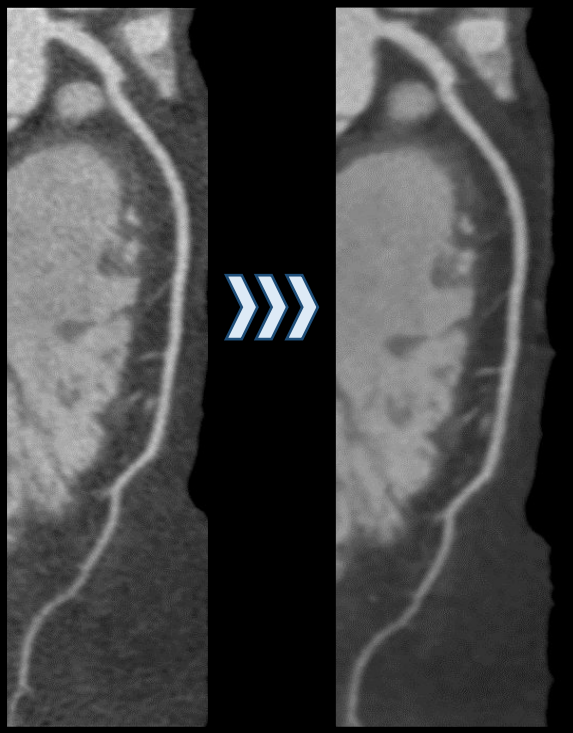
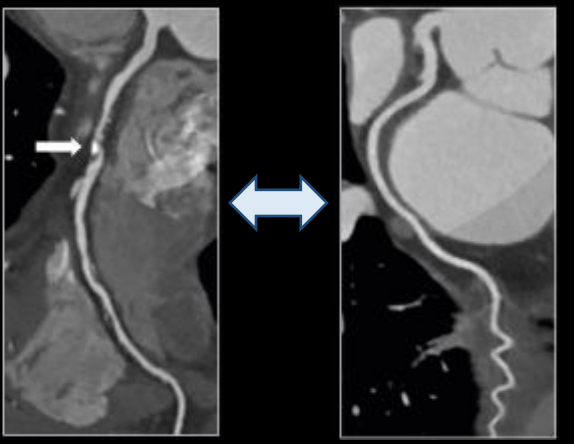


The role of molecular fingerprint in the diagnostics of coronary artery disease



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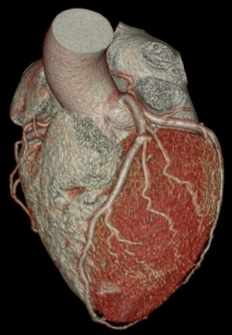
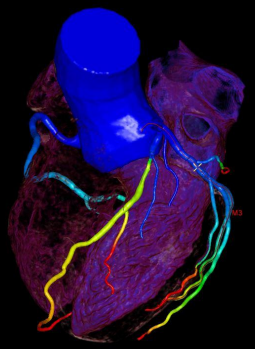
Student research

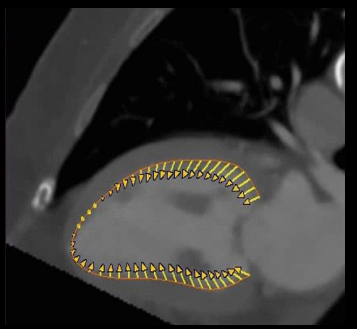
Role of Coronary Angiography in stable angina



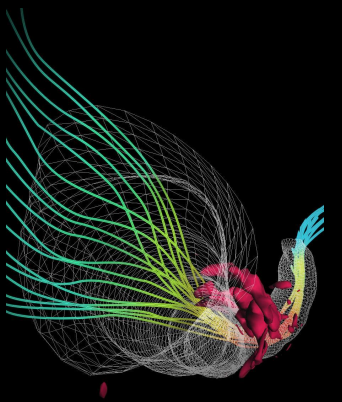
Anatomy
Coronary artery disease



Ischemia detection
FFR-CT
Perfusion CT



Left ventricular function
CT strain



Radiomics, plaque analysis

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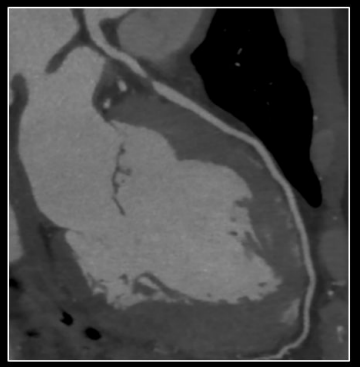
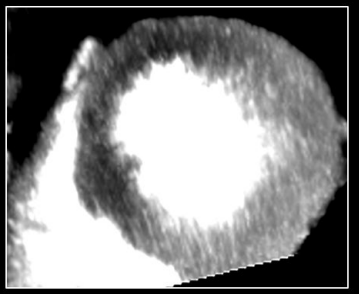
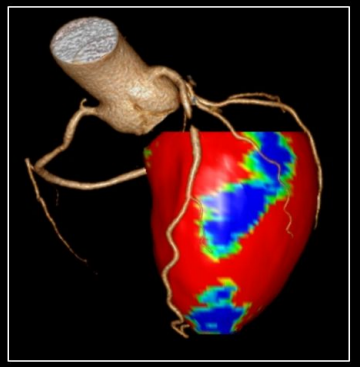
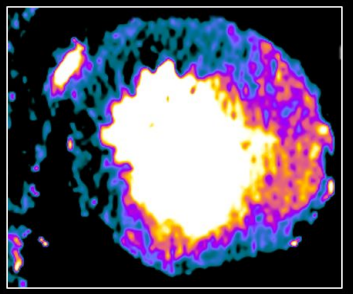
Student research

Perfusion CT in the identification of significant lesions









CCTA DPCT ICA

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Thank you for your attention!