Coronary CT Angiography in revascularization procedures: findings, artifacts, and problems

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Learning objectives

- Describe commonly used reperfusion procedures (stent placement bypass surgery)
- Describe Cardiac-CT artifacts, limitations, and methods to counter these problems
- Propose a methodological system for reading this studies, using the most out of multiplanar reconstruction (MPR), curved MPR, volume rendering and MIP

Background

Advances in therapy of ischemic heart such as percutaneous stent placement and bypass surgery, have had a positive impact in mortality and morbidity. However, given the systemic nature of atherosclerosis, other stenosis may progress to become symptomatic and technical failure of the therapy implemented may occur (such as restenosis and occlusions). Post-therapy cardiac computer tomography (CT) is now seen as a viable alternative the gold standard (Conventional Angiography). However it faces specific challenges given the size of the structures to assess, the artifacts caused by the procedure and the comorbidities.

Knowledge of the procedures, anticipation of the artifacts and a methodological system to read these studies are essential to improve accuracy of Cardiac-CT studies.

Stents pose a significant challenge: their size is usually small (2.5 to 5 mm), they may be placed anywhere and may have very high attenuation. Obese, tachycardic or those with severelly calcified arteries are also more difficult to assess.

Performance for assessment coronary stents is reasonable but not perfect: Usually about 13% of the "stented" arteries were inconclusive. Of the others assessed, sensitivity and specificity values are about 84% and 91% respectively.

Poor candidates for cardiac CT are those arrythimic patient, tachycardic with counterindication for betablockers, with small stend diameter.

In cardiac surgery, results are usually better: with sensitivity and specificity exceeding 95%.

Findings and procedure details

Cardiac CT angiograms were performed to patients submitted to revascularization procedures (stent or surgical bypass). A 64-slice scanner (GE Lightspeed®), was used, using a retrospective cardiac gating to acquire isotropic volume. The different approach to stent or bypass submitted studies will be addressed, regarding the use of multiplanar reconstruction and findings.

Artifacts

Motion related artifacts Fig. 2 on page 13

- high rates
- Irregular rates
- Paradoxical ventricular motion patterns
- Decrease cardiac output

Beam hardening artifacts

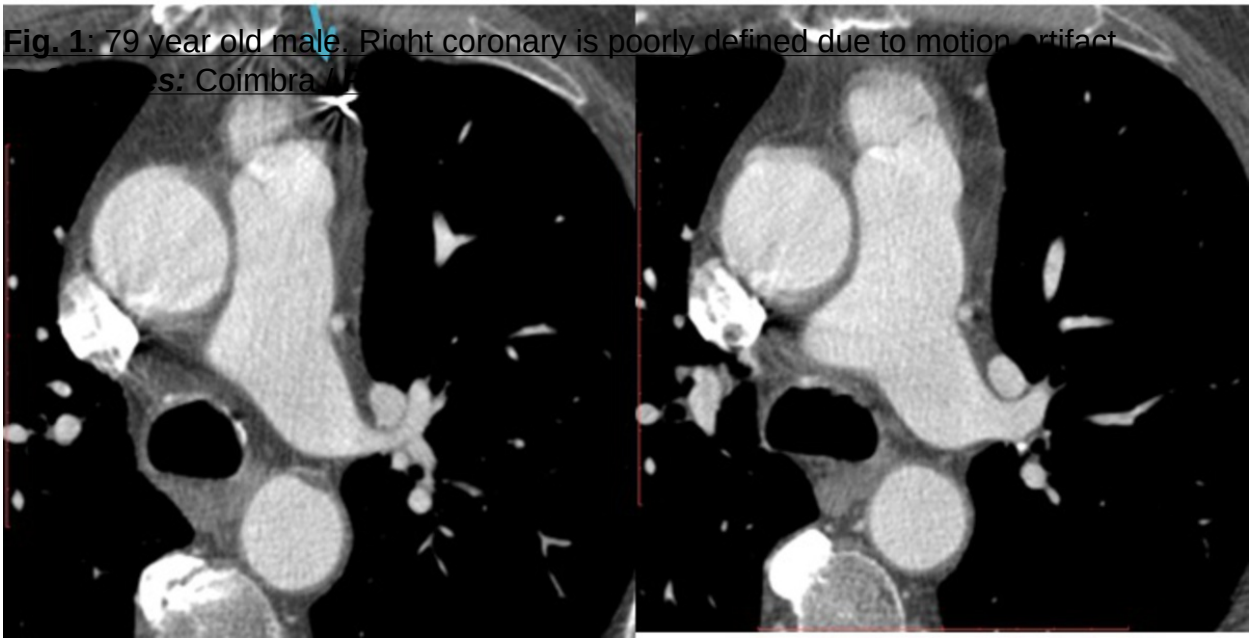

Fig. 1: 79 year old male. Right coronary is poorly defined due to motion artifact
Images: Coimbra

- caused by absrption of lower energy photons
- Virtual loss of density surrounding the metal (may be countered by dedicated image reconstruction algorithms)

Blooming

- Apparent increase in size
- Caused by partial volume effects
- Causes artificial lumen narrwing in stents

Increasing acquisition quality

Motion artifacts

- Premedication with Beta-blockers and Nitroglycerin
- Fast-gantry rotation
- Careful positioning of the heart at the table center

Spatial resolution

- Thinner collimation (increases noise and radiation)
- Use a smaller Field Of View for heart and a second to cover entire acquisition
- Use a intermediate to hard kernel level ("Bone" algorithm)

Questions to answer - What to state on the examination?

- Is the in-stent portion diagnostic quality?
- Is there stenosis inside the stent?

Looking at the MDCT:Stents

1. Multiplanar reconstructions
2. Used curved MPR
3. If artifacts cannot be excluded then lumen is nondiagnostic.

Presence of distal contrast does not exclude in-stent stenosis.

Major complications are stent-thrombosis and restenosis.

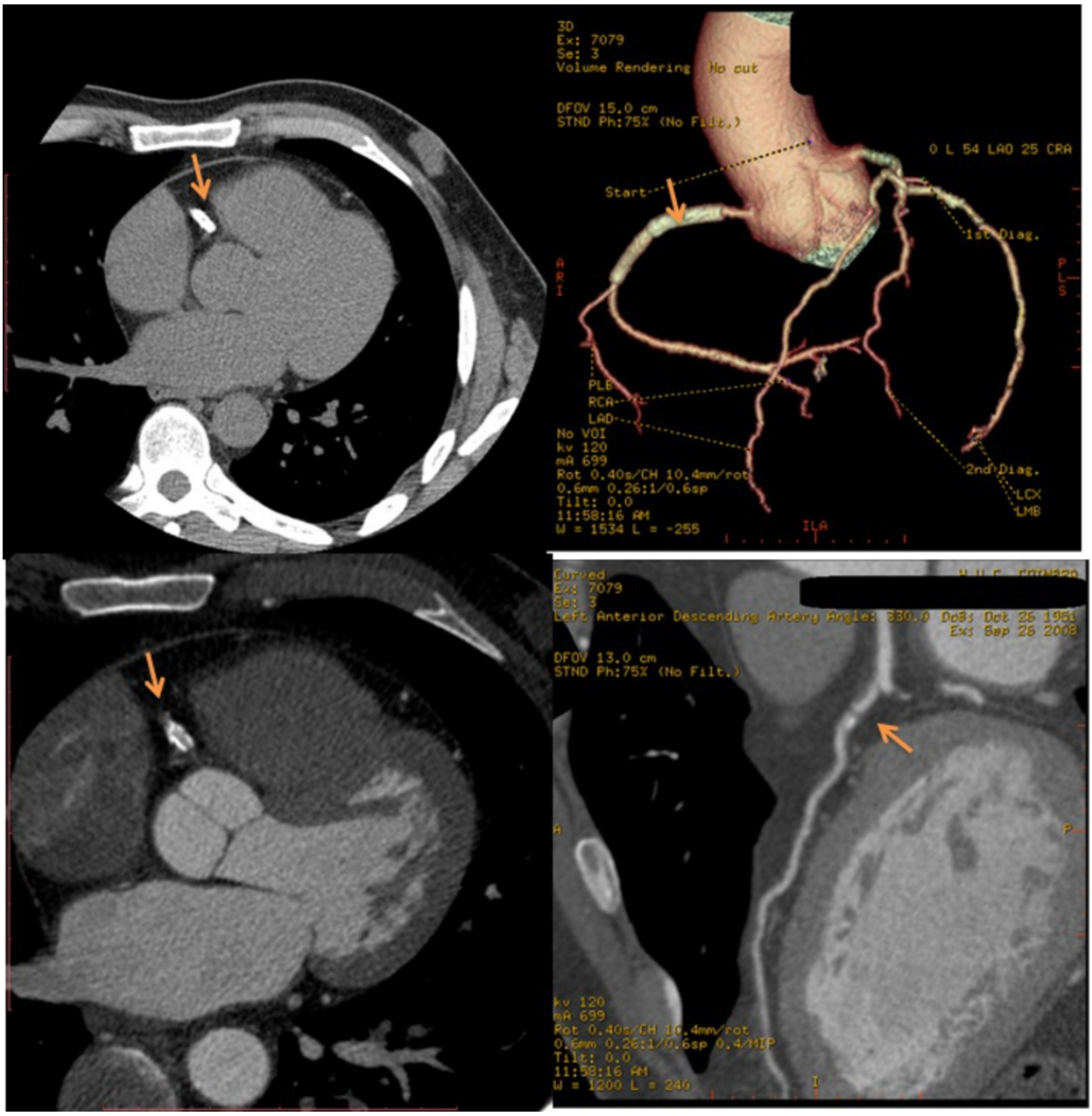

Fig. 3: 59 year old patient with stent in right coronary artery. No stenosis was found in the stent. Anterior descending coronary artery presented partially calcified plaque which caused stenosis of circa 50%. Top-left: non contrast study showing stent Top-right: VRT reconstruction of the coronary tree Left-bottom: Contrast-enhanced showing stent Right-bottom: Oblique MPR of the left descending artery showing a mixed soft-tissue and calcified plaque causing 50% stenosis.
References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

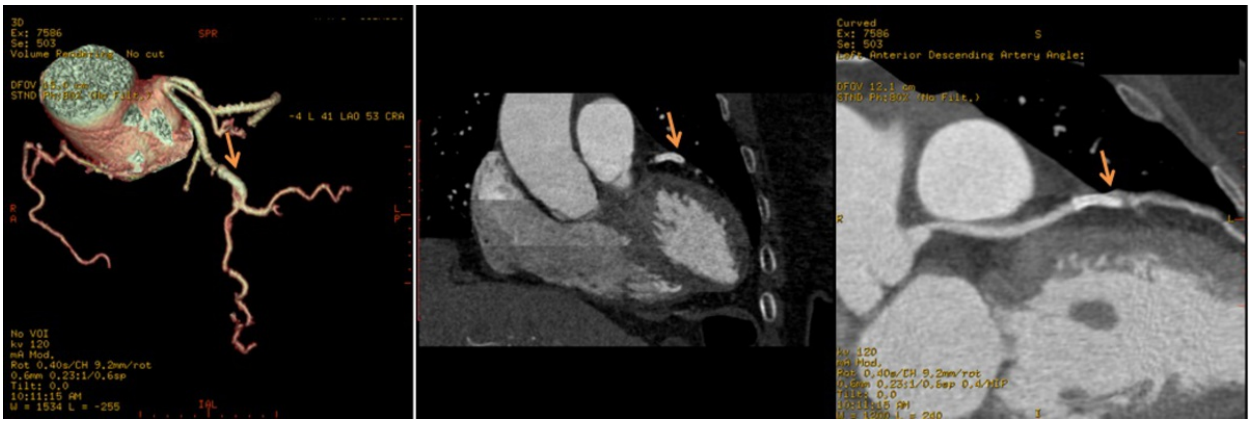

Fig. 4: 5 year old female patient with percutaneous stent placement in the anterior descending artery. Perfusion cyntigraphy with 99-TCm showed apical perfusion deffect in the 17th segment (left anterior descending artery). Although the stent was apparently permeable, distal to it there is na atherosclerotic plaque which conditions a significant stenosis. Left: 3D reconstruction of the coronary artery, showing stent localtion Center: Coronal MPR showing stent permeability Right: Curved MPR of the descending coronary artery showing a plaque distal to the stent.

References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

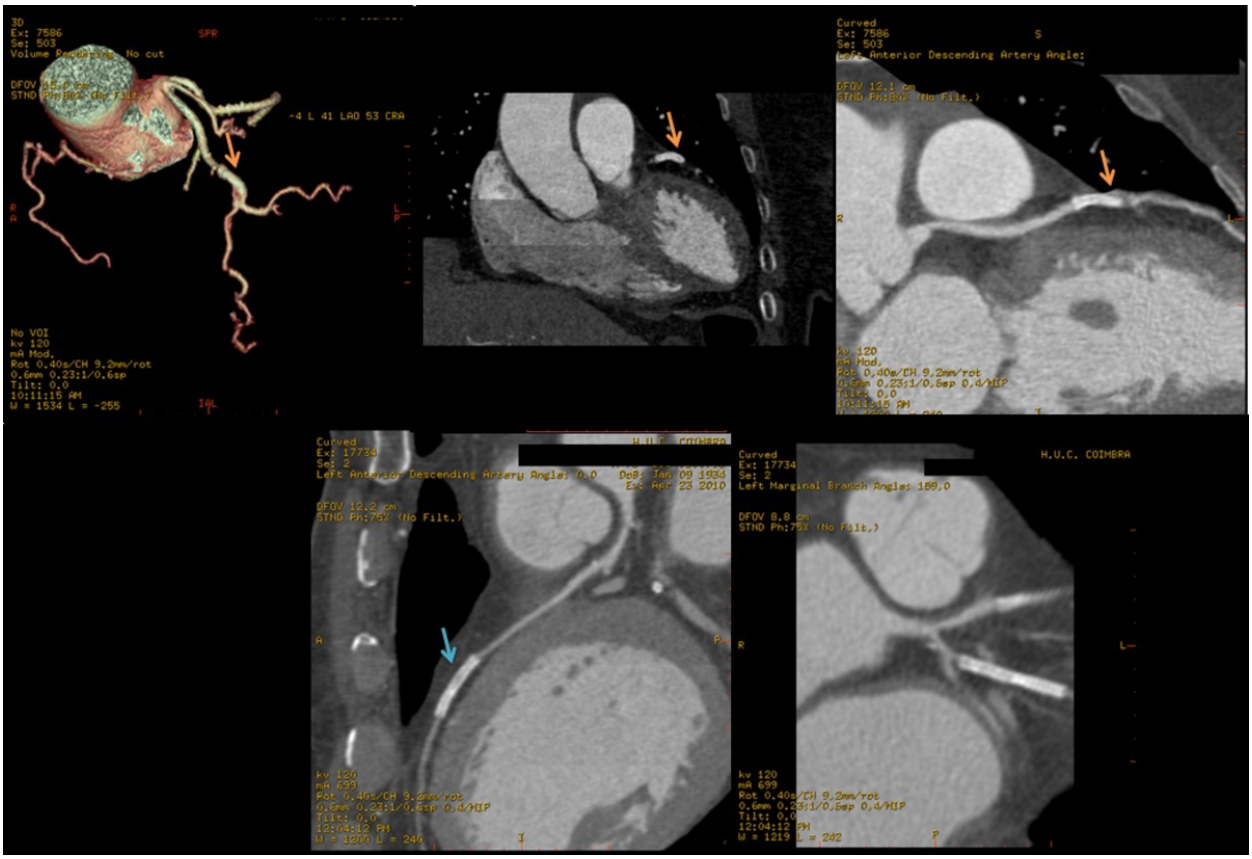

Fig. 5: 76 year old male patient with ischemic signs in the stress perfusion cyntigraphy (segments 4 and 10) in the inferior wall on stress. Previously submitted to coated stent revascularizaition of the descending anterior artery, first diagonal and first obtuse marginal. Top-center: 3D reconstruction of the coronary artery, showing stent location Top-left: Curved MPR of the right coronary artery showing a soft tissue plaque, causing a stenosis <50%. Top-right: Curved MPR of the first diagonal showing permeable coronary stent. Bottom-left: Curved MPR of the descending coronary artery showing permeable coronary stent Bottom-right: : Curved MPR of the first obtuse marginal showing permeable coronary stent

References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

Fig. 6: 61 year old, multiple previous myocardial infarcts. Note the "blooming" effect in the right coronary stent, and the myocardial thining at the apex.
References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

Looking at the MDCT:Surgery

1. Overview anastomisis (start by the 3D)
2. Evalute grafts in axial and orhogonal MPR planes

3. Evaluate anastomosis and run-off
4. Evaluate aorta and left-ventricle size

Note: It is essential that the whole graft is included in the acquisition.

The most common cause of saphenous graft failure is thrombosis in the first year and after that atherosclerotic changes ensue.

Arterial grafts usually have longer life span.

MDCT, unlike angiography, allows assessment of occluded grafts

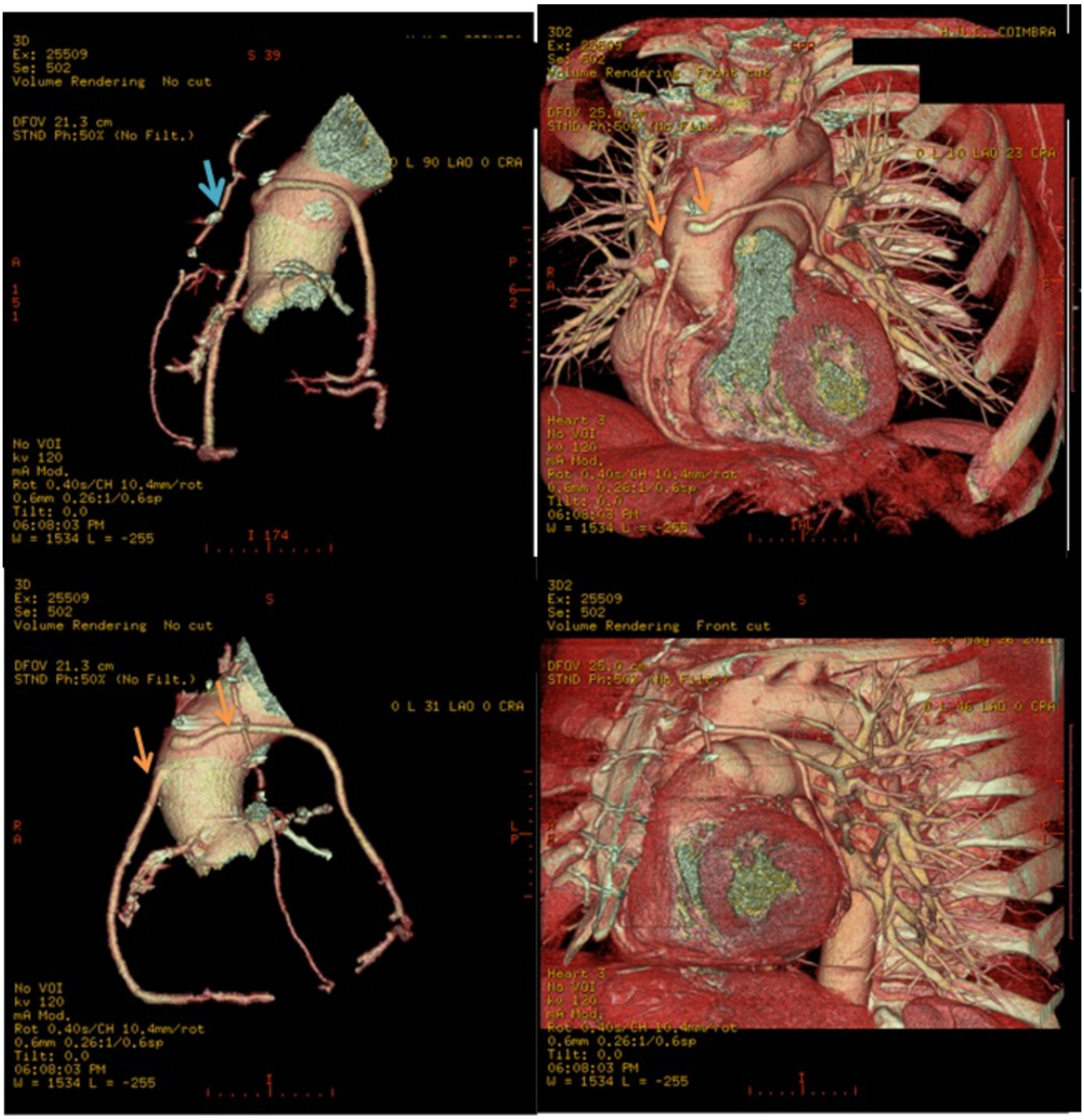

Fig. 7: 68 year old male with atypical chest pain, submitted to revascularization surgery: bypass from left internal mamary to anterior descending artery, saphen vein to right coronary artery and saphen vein to circunflex artery. Native coronary artery assessment was impossible due to calcified plaques , possibly with multiple critical stenosis. Top-left and bottom-left: VRT reconstruction of the vessels Right-top and Right-bottom: VRT reconstruction of the heart better depicting the saphen-coronary anastomosis

References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

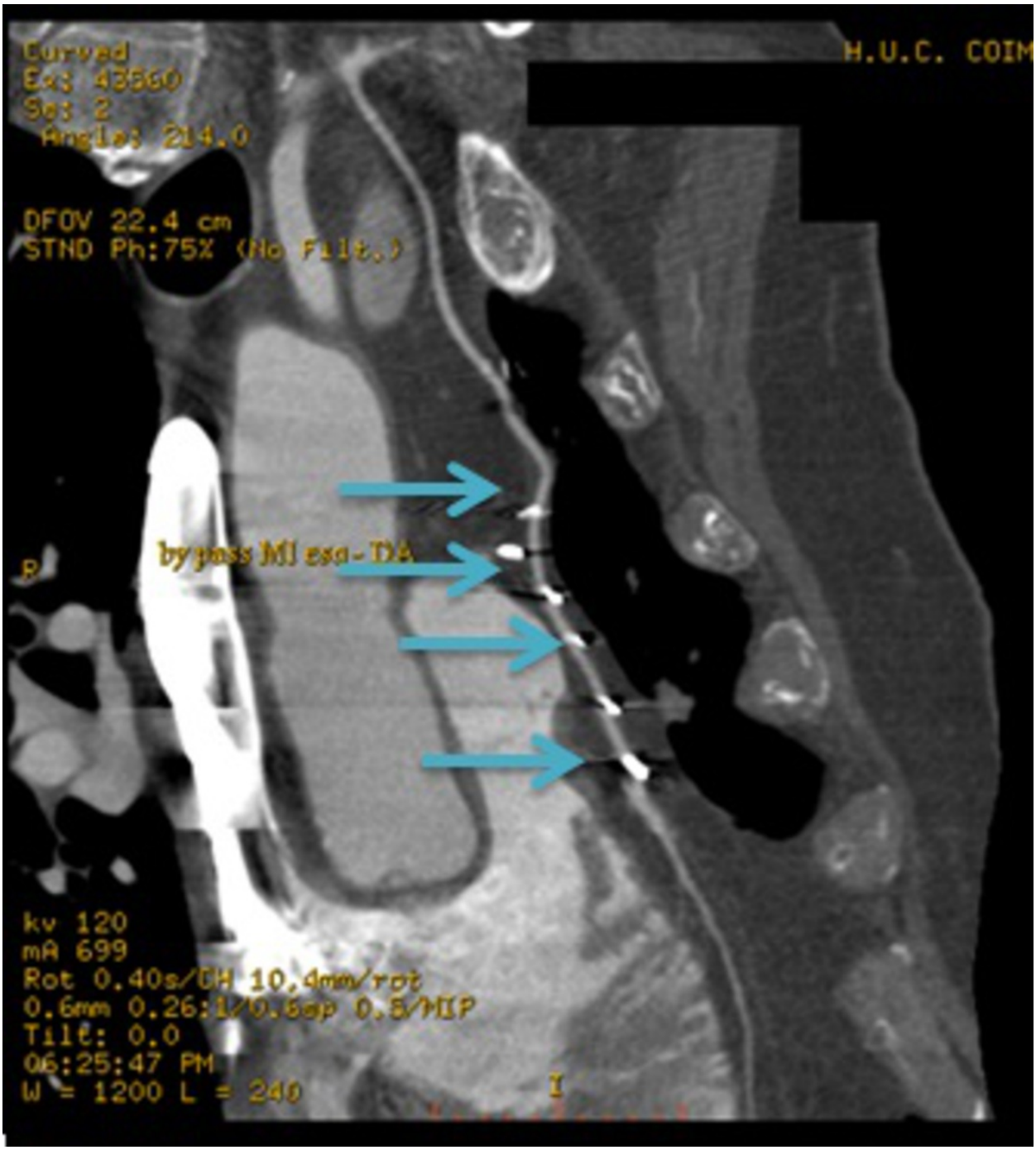

Fig. 8: 71 year old patient submitted to coronary artery by-pass surgery. Curved MPR may show less beam-hardening than axial section.
References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

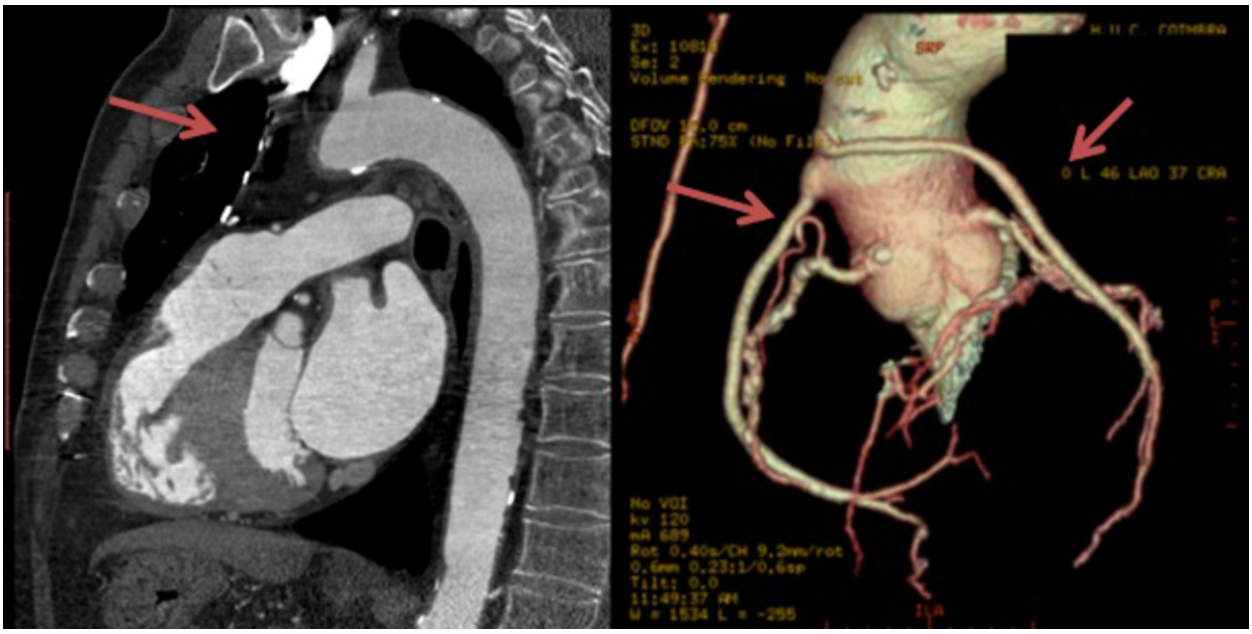

Fig. 9: 76 year old male patient, submitted to coronary-bypass: saphen to right coronary, saphen to 1st marginal obtuse and left internal mamary artery to descending anterior artery.
References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

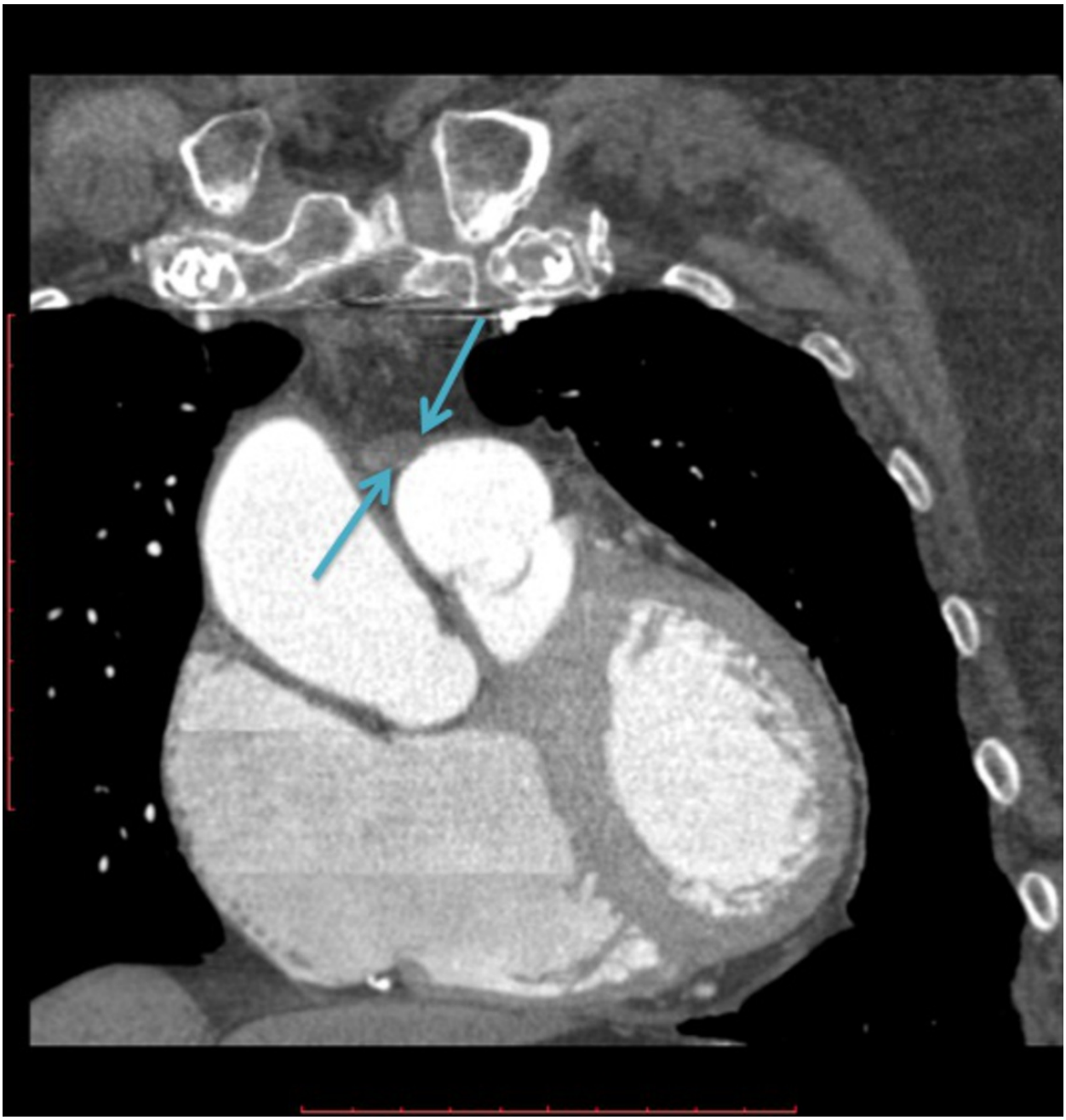

Fig. 10: 84 year old patient with previous coronary by-pass: saphen to left marginal artery, occluded.
References: Medical Imaging, Faculty of Medicine of Coimbra, University Hospital of Coimbra - Coimbra/PT

Images for this section:

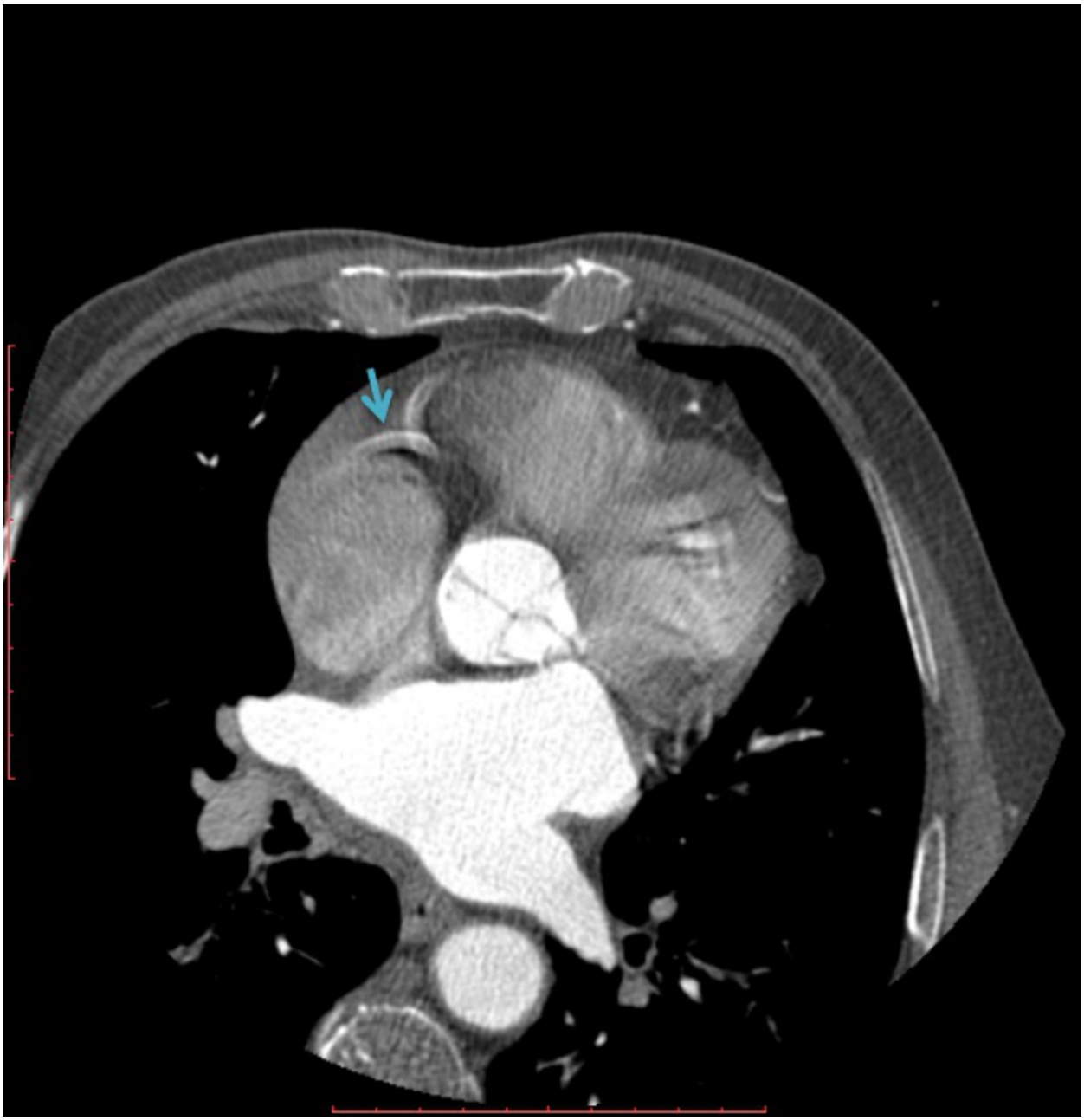

Fig. 2: 79 year old male. Right coronary is poorly defined due to motion artifact

Conclusion

Cardiac-CT is currently a viable method for assessing coronary abnormalities. Procedural changes to the normal anatomy provide a challenge both in protocol planning and interpreting these examinations.

It is important for Radiologists to acknowledge these challenges and the possible limitation in order to implement the most useful resources, and to convey the most adequate report.

In surgical revascularization, results have been better than in stent revascularization. We expect that further improvement in non-invasive diagnostic technique will continue, possibly making this first-line option for re-evaluating after revascularization procedures.

Personal information

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