How we manage radiation protection in our country
Russian Association of Radiology

Optimisation of radiation dose reduction in coronary computed tomographic angiography

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Coronary computed tomography angiography (CTA) is a non-invasive modality that is commonly used as an alternative to invasive coronary angiography for the investigation of coronary artery disease. But coronary CTA has been criticised for exposing patients to high doses of radiation. Recent years have seen an overall increase in the use of CTA for imaging of the heart and coronary arteries. The downside of this is the increase in radiation dose, which may pose a risk to the population, especially children and young patients.

Purpose

- To describe the techniques and new technologies available for dose reduction in coronary CTA.
- To show the main algorithm that we recommend using for radiation dose reduction in coronary CTA in adults and young patients.

Strategies to reduce radiation dose

The radiation dose in coronary CTA varies greatly (from 5 to 30 mSv), depending on the scan parameter setting. Factors affecting radiation dose include tube voltage, tube current, ECG-gating (prospective or retrospective), pitch, scan length and shielding.

Coronary CTA should be carried out with dose-saving strategies whenever possible. There are a lot of different strategies for the reduction or minimisation of radiation exposure during coronary CTA, they include:

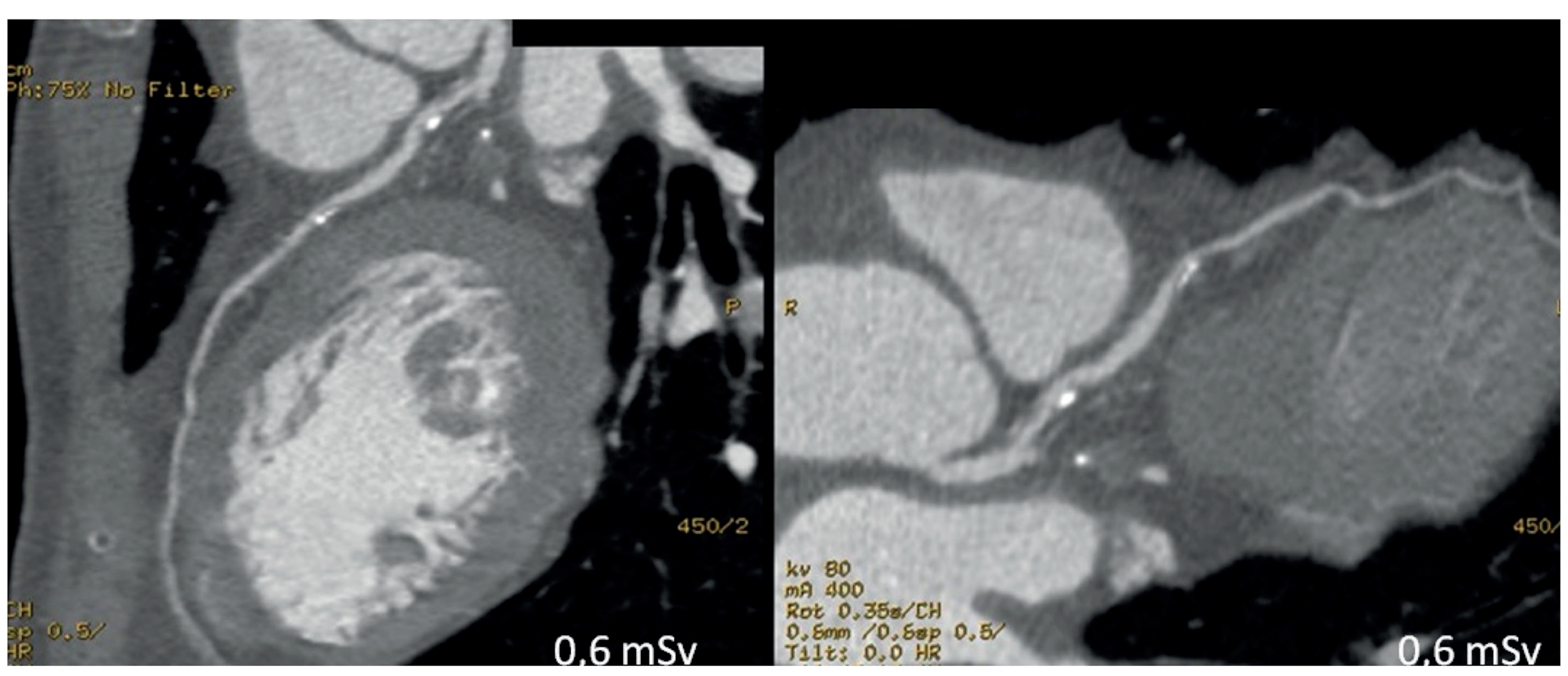
- Tube current modulation
- Adjustment of tube voltage and tube current
- Adjustment of pitch value
- Prospective ECG-gating
- Shortened scan length
- Decreased scan time
- Faster data acquisition

Depending on the strategy chosen, the radiation exposure can be reduced significantly compared to standard scanning protocols.

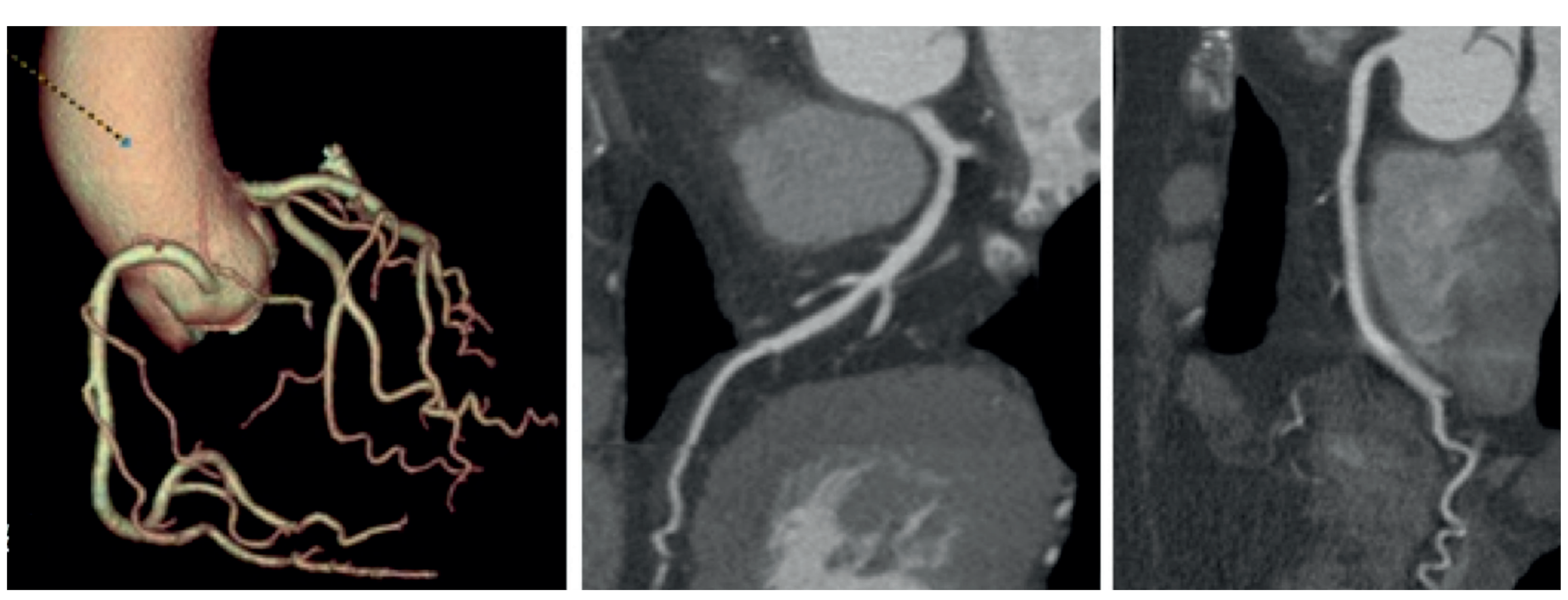
Our experience

With modern CT scanners (ASIR, Veo) low-dose coronary CTA can be performed without a loss in image quality. The use of adaptive statistical iterative reconstruction (ASIR) can reduce the tube voltage (100 kV and less), which in turn can decrease the radiation dose.
In our radiology department we perform low-dose coronary CTA in adults and young patients. We use prospective ECG-gating and low tube voltage. Low tube voltage leads to an increase in image noise. But due to iterative image reconstruction it can substantially reduce radiation dose without compromising image quality.
The standard acquisition technique of coronary CTA is performed using retrospective ECG-gating. Retrospective ECG-gating data acquisitions allow for data reconstruction of the whole scan volume at any time-point within the cardiac cycle. Prospective ECG-gating, the opposite to retrospective ECG-gating, is performed during the fixed R-R interval, usually for 60-70% of the R-R interval. We use prospective ECG-gating for patients with a BMI of less than 31 kg/m2 and HR lower than 65 bpm.
A low effective dose of approximately 0.6 mSv was achieved by using a prospective ECG-gated technique on a slim female patient in which the tube voltage was reduced to 80 kV and the tube current was 400 mA (Fig. 1). Clinical case 1 and 2 illustrate other examples of low-dose coronary CTA.

Fig. 1: CTA examination with prospective ECG-gating. Tube voltage 80 kV; tube current 400 mA; scan range 104 mm; CTDI 3,09 mGy, DLP 40,63 mGy/cm, E 0,6 mSv.

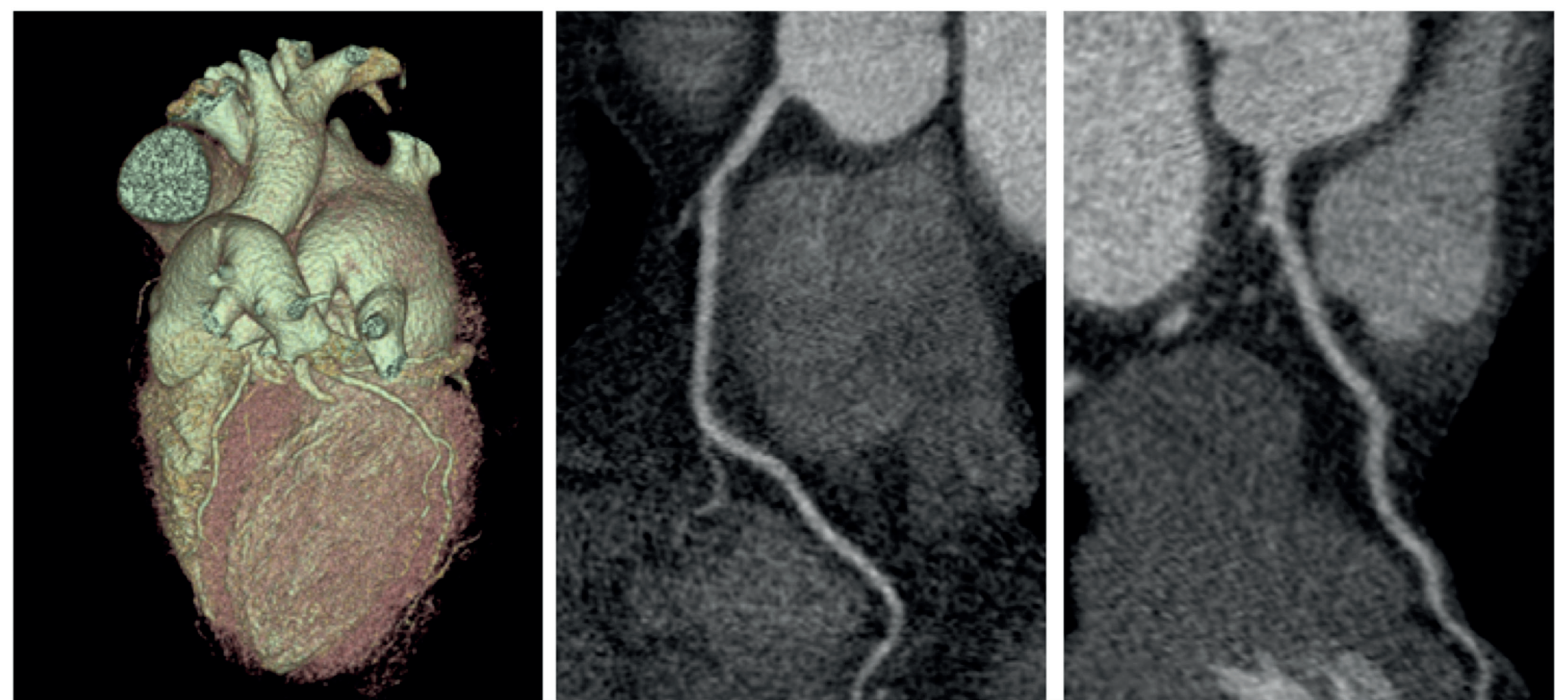


Clinical case 1
Fig. 2: 3D and curved MPR coronary CTA



A 41-year-old male with suspected coronary arteries disease. BMI and HR were 22.7 kg/m2 and 44/min respectively.
Technical parameters of coronary CTA were: prospective ECG-gating, tube voltage – 80 kV, tube current – 550 mA; image matrix – 512x512; slice thickness – 0.625 mm, type of image reconstruction – ASIR 40%. Patient was examined with contrast medium with iodine concentration 270 mg I/mL.
Thanks to reduction of tube voltage and use of prospective ECG-gating, radiation dose was decreased to 1.37 mSv.

Clinical case 2
Fig. 3: 3D and curved MPR coronary CTA



Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Cine	S27.000-I150.500	2.75	49.56	Body 32
200	Axial	S15.000-S15.000	4.33	2.16	Body 32
4	Cine	S21.750-I152.625	6.50	113.81	Body 32

1,59 mSv

A 51-year-old male with suspected coronary arteries disease. BMI and HR were 31 kg/m2 and 52/min respectively.
Technical parameters of coronary CTA were: prospective ECG-gating, tube voltage – 80 kV, tube current – 550 mA; image matrix – 512x512; slice thickness – 0.625 mm, type of image reconstruction – ASIR 40 %.
Thanks to the reduction in tube voltage and the use of prospective ECG-gating, the radiation dose was decreased to 1.59 mSv.

Summary

Technique: Definition of a time-point during mid-diastole (60-70% of the R-R interval), when the heart is almost motionless, and a tube voltage of 80-100 kV.

Patients: Young and middle-aged patients, pre-menopausal women (because of the direct breast exposure), patients who might in the future undergo repeated coronary CTA examinations.

Drug administration: Beta-blockers can be administered to patients to lower their HR. Moreover, in order to obtain good coronary images, we recommend sublingual nitrates.

Specification: Applicable in patients with a regular heart rate < 65/min and in patients with BMI less than 31 kg/m2. For a reduction in image noise we recommend using the latest adaptive statistical iterative reconstruction (ASIR) technology. ASIR is an alternative to the classic reconstruction CT technique– filtered back projection (FBP). Application of the ASIR-algorithm can significantly improve overall image quality, especially in obese patients.

For the application of radiation dose reduction strategies in coronary CTA we recommend a simple algorithm (Fig 4). The use of this simple algorithm in clinical practice is accompanied with a significant decrease in radiation dose (40-60 % and more) without a loss of image quality or diagnostic information.

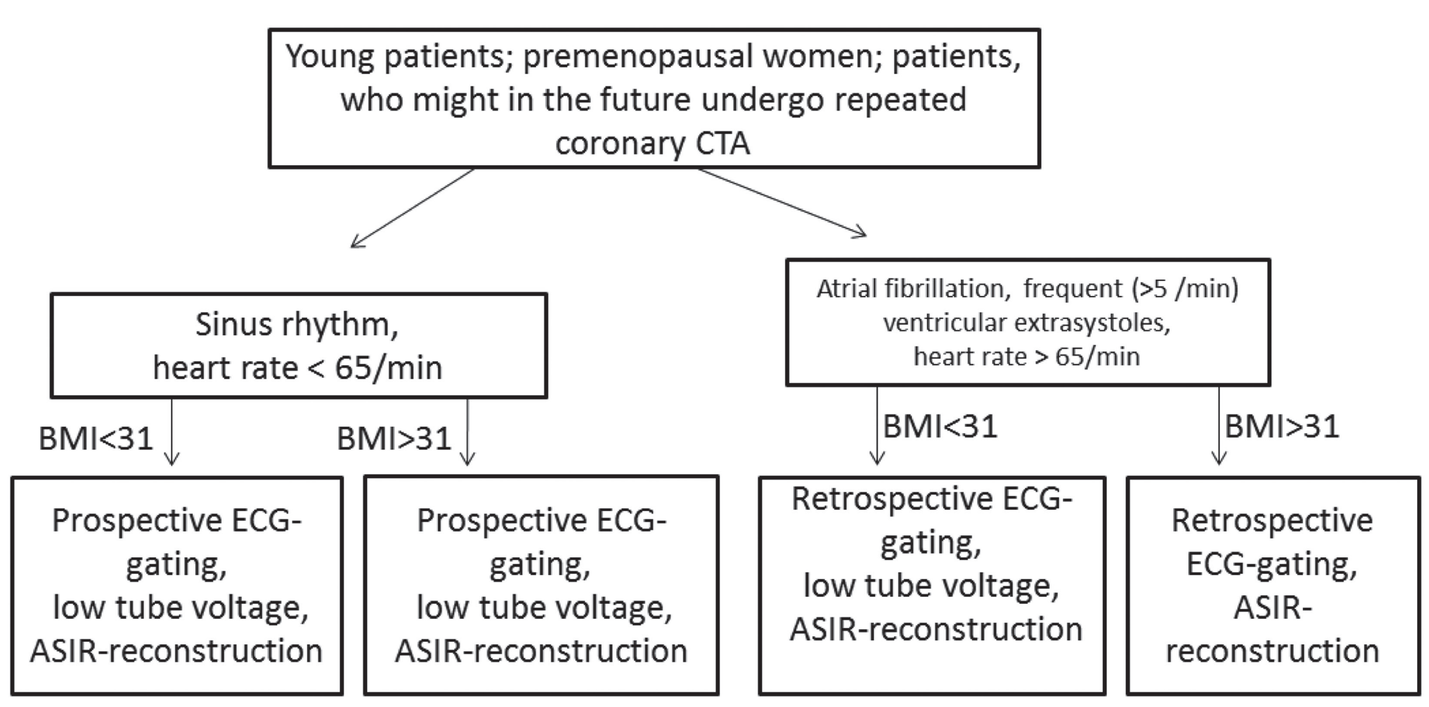


Fig. 4: Radiation dose reduction algorithm in coronary CTA.