

Radiation Dose Associated With Non-invasive Coronary Angiography Performed with 256-slice Computed Tomography

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Purpose

1. Coronary computed tomography angiography (CCTA) has become a useful non-invasive diagnostic imaging modality in the examination of coronary artery disease. The number of cardiac diagnostic tests that are performed has increased notably in recent years (Ref.1).

2. Since the exposure to ionizing radiation can be harmful, monitoring the radiation exposure that is received during CCTA in daily practice is of vital importance for the development of dose reduction strategies (Ref.2). Fast-paced technical innovations provide new opportunities for radiation dose reduction. Prospectively ECG-triggered scan protocols result in significantly lower effective doses (Ref.3) ([Fig. 1](#) on page 2).

The 256-slice CT has a very high diagnostic accuracy and negative predictive value (>98%) in detecting coronary stenosis as compared to the invasive coronary angiography (ICA). The high spatial (isotropic reconstructed voxel size 0.67x0.67x0.67 mm³) and high temporal resolution (36-135 ms) permit a robust non-invasive visualisation of the coronary arteries.

3. We sought to estimate the radiation dose associated with CCTA performed with 256-slice CT scanner (256-CCTA) in routine clinical practice in a non selected patient population. Furthermore, we sought to identify independent factors contributing to radiation dose.

Images for this section:

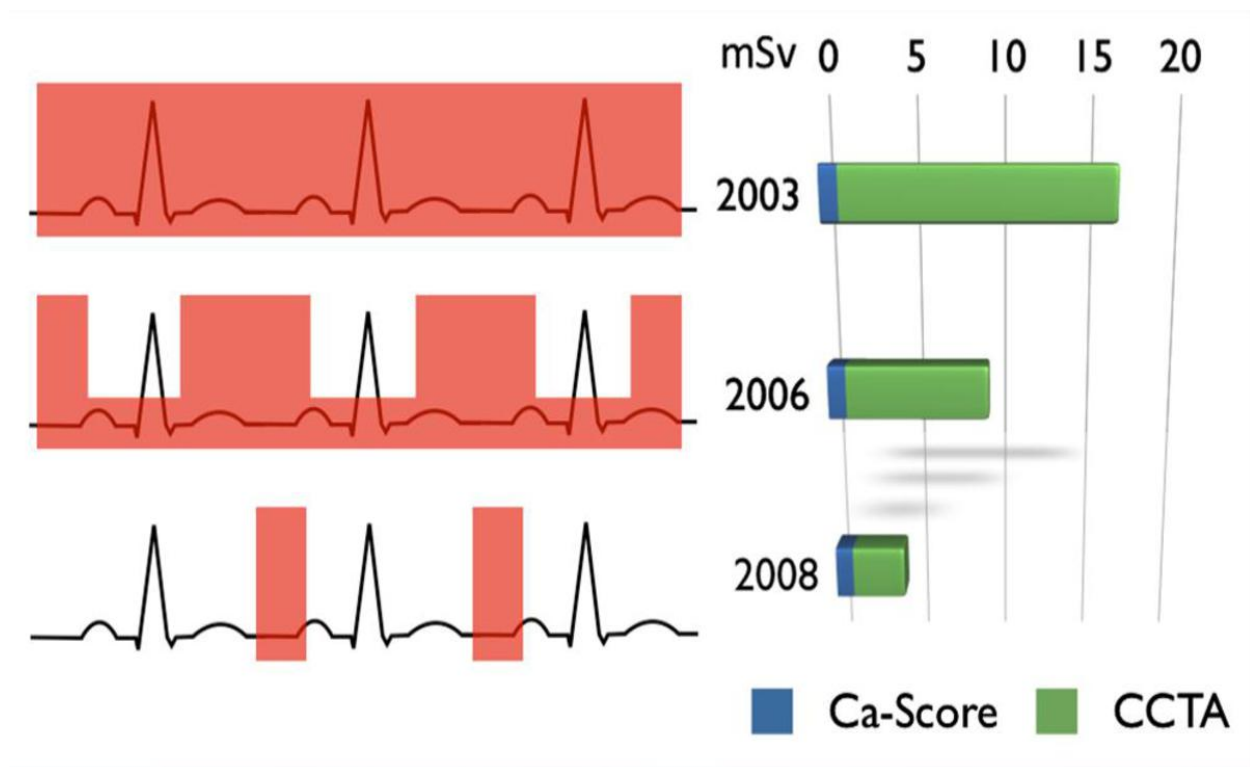


Fig. 1: ECG gating and the associated radiation doses. Top row: Retrospective ECG gating Middle row: Retrospective ECG gating with dose modulation Bottom row: Propective ECG triggering CCTA: Coronary Computed Tomography Angiography

Methods and Materials

We estimated the radiation dose of 496 patients who underwent 256-CCTA at the Heart Center, Semmelweis University between March and November 2011.

Radiation dose parameters were extracted from the dose exposure records and scan reports were used to collect patients' baseline characteristics ([Fig. 2](#) on page 4). The DLP (dose length product), a standard measure of the total amount of radiation was recorded (Ref.4). The DLP was converted into millisieverts by multiplying it by a body region-specific scaling factor (k-factor=0.014) (Ref. 5 and 6).

Data analysis was performed using Statistica version 10 (StatSoft, Inc., Tulsa, OK). All continuous variables were expressed as mean $\pm$ SD or median with interquartile ranges, whereas categorical variables were expressed as percentage. Differences in continuous variables were assessed using Student paired t test or Mann-Whitney U test as appropriate.

We have analyzed the data of 496 consecutive patients (304 male, 61%). The mean age was 58.8($\pm$ 11.7) years, 256 (51%) patients are older than 60 years. ([Table 1](#) on page 5)

We measured body parameters of patients (height and weight), and calculated the Body Mass Index. The mean BMI was 28 ($\pm$ 4.5). We found that 114 patients have a lower BMI than 25 (23%), 203 patients are between 25-30 (41%), and 179 patients are above 30 (36%).

383 of 496 CT-scans (77%) were performed with prospective scanning mode. The heart rate was available of 196 patients (Ref.7). The medical history contained CABG or PCI in 187 patients (37%) and 204 (41%) had coronary artery disease earlier ([Fig. 3](#) on page 6 [Fig. 4](#) on page 7) .

Images for this section:

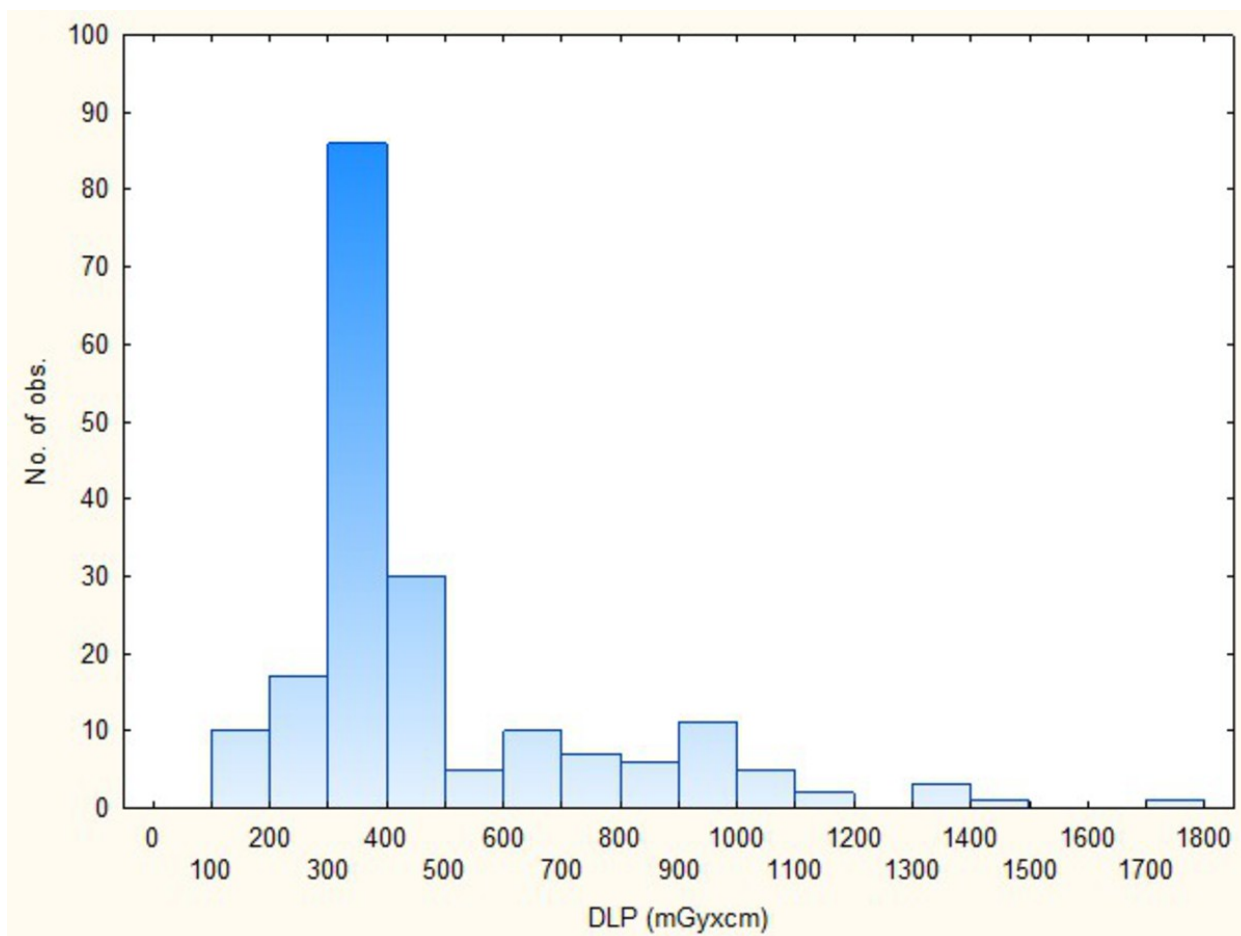


Fig. 2: The distribution of radiation doses associated with coronary CT angiography in the Heart Center, Semmelweis University. Median DLP: 390 mGyxcms

N=496	
Age (Mean±SD)	58.8(± 11.7) years
Gender	304 male (61%); 192 female
BMI (Mean±SD)	28 (± 4.5)
BMI under 25	114 (23%)
25-30	203 (41%)
above 30	179 (36%)
Status post PCI & CABG	187 (37%)
Status post CAD	204 (41%)

Table 1: Baseline characteristics



Fig. 3: Left panel: curved multiplanar reconstruction of the venous bypass graft to the posterior descending artery. Right panel: volume rendered image. Radiation dose: 8.2 mSv (DLP: 592 mGyxcn)

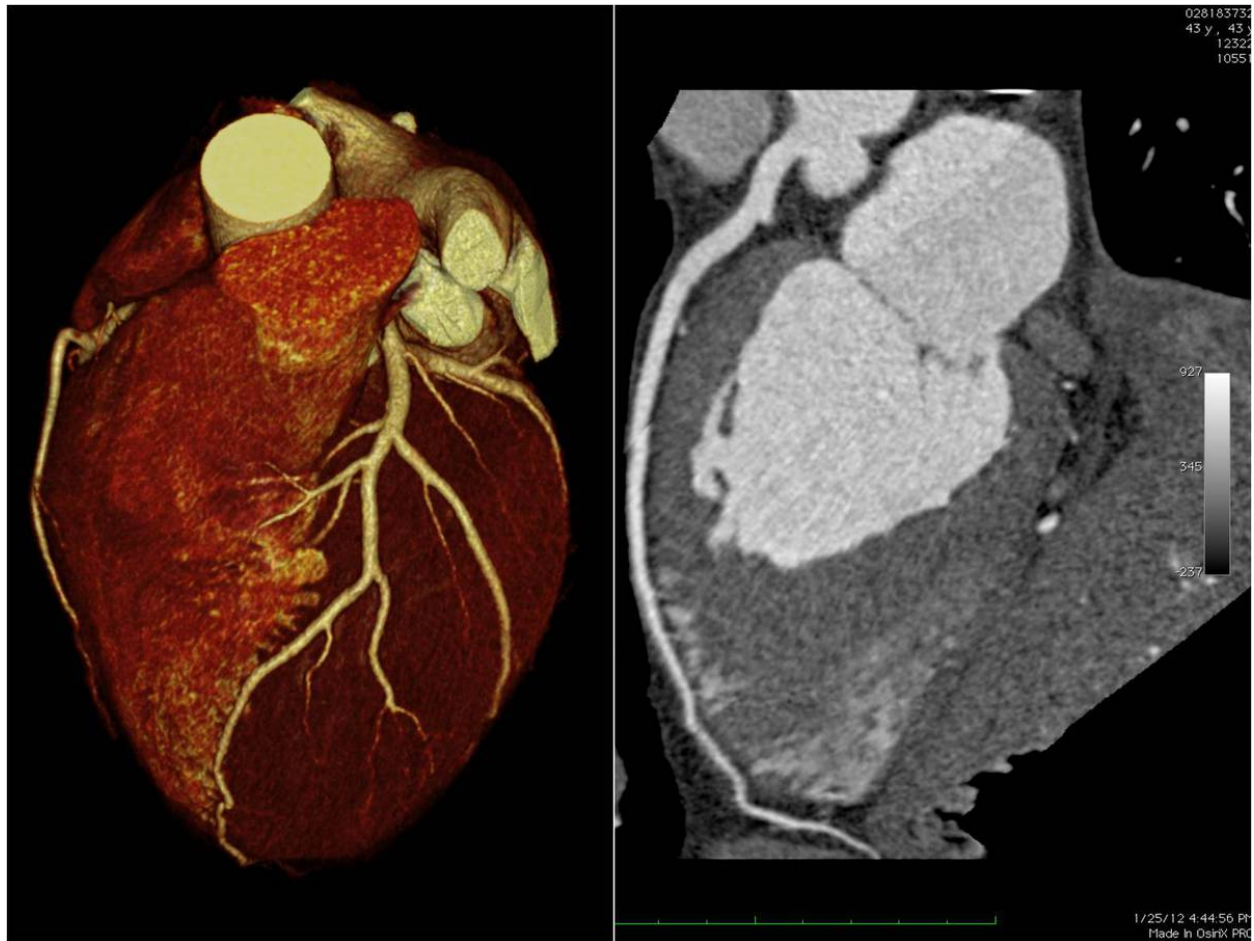


Fig. 4: Left panel: volume rendered image. Right panel: curved multiplanar reconstruction of the venous bypass graft to the posterior descending artery. Radiation dose: 2.1 mSv (DLP: 150 mGyxcn)

Results

The median DLP of 496 performed CCTA scans was 390 mGyxcn [370-609], corresponding to an estimated radiation dose of 5.5 mSv.

We found significant difference in radiation doses related to the following variables:

-patients with low heart rate (<65/bpm) versus high heart rate (#65bpm) (383 [366-417] versus 692 [404-961] mGyxcn, $p<0.0001$, respectively);

-normal weight (BMI#25kg/m²) versus overweight (BMI>25kg/m²) patients (369 [238-417] versus 415 [378-663] mGyxcn, $p<0.0001$, versus) [Fig. 5](#) on page 8;

-patients under 60 years of age versus patients above 60 years of age (382 [360-484] versus 422 [379-701] mGyxcn, $p<0.0001$, respectively) [Fig. 6](#) on page 9;

-prospective ECG triggering versus retrospective ECG gating (382 [363-424] versus 907 [710-1073] mGyxcn, $p<0.0001$, respectively) [Fig. 7](#) on page 10.

We found no difference regarding doses associated with gender

-female versus male patients (384 [363-609] versus 396 [374-613] mGyxcn, $p=0.076$, respectively) [Fig. 8](#) on page 11;

Independent factors associated with radiation dose were the age of the patient ($p<0.0001$) and the utilized ECG gating mode (<0.0001).

Images for this section:

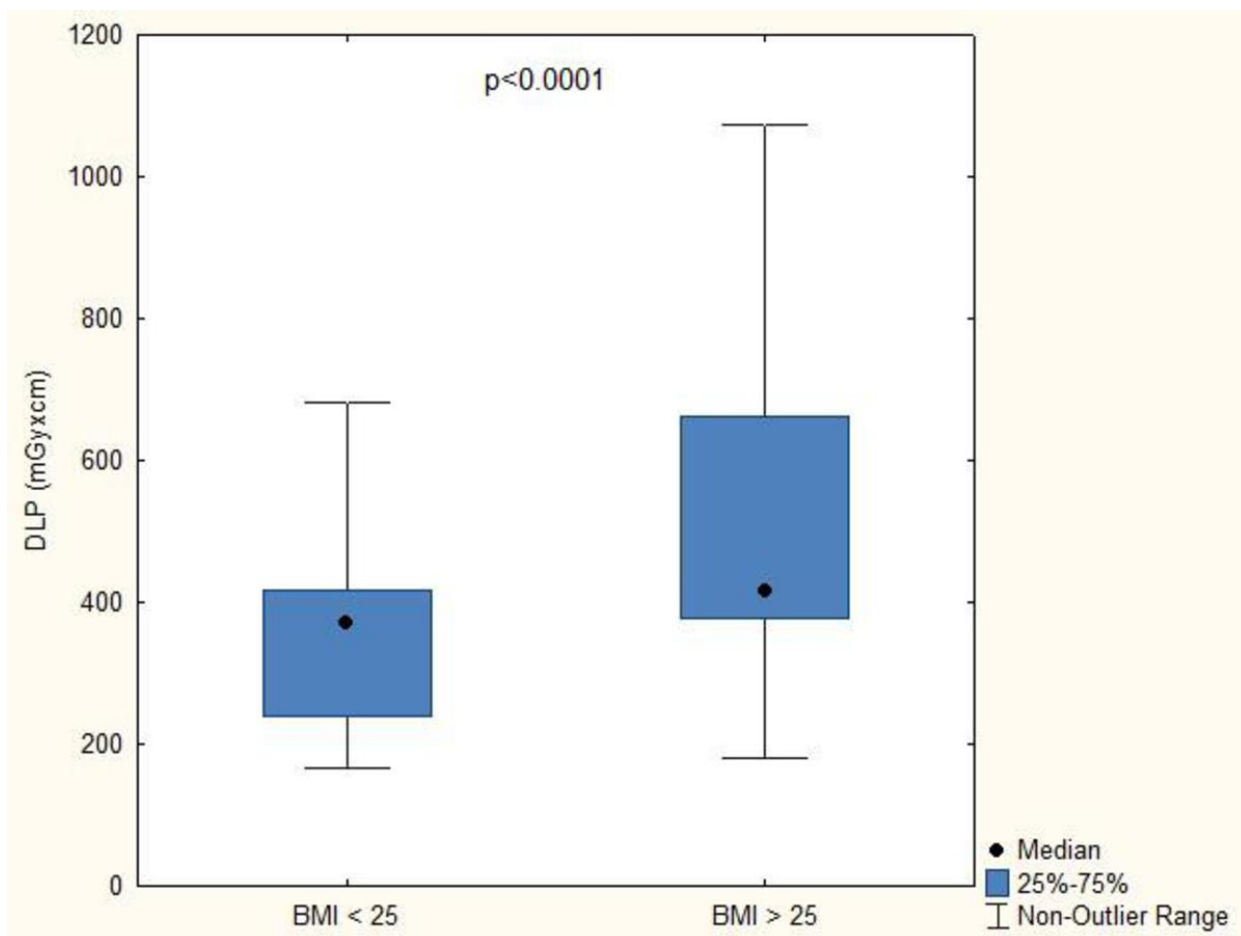


Fig. 5: Radiation doses associated with body weight. Normal weight patients (BMI≤25kg/m²) versus overweight patients (BMI>25 kg/m²), (369 [238-417] versus 415 [378-663] mGyxcm).

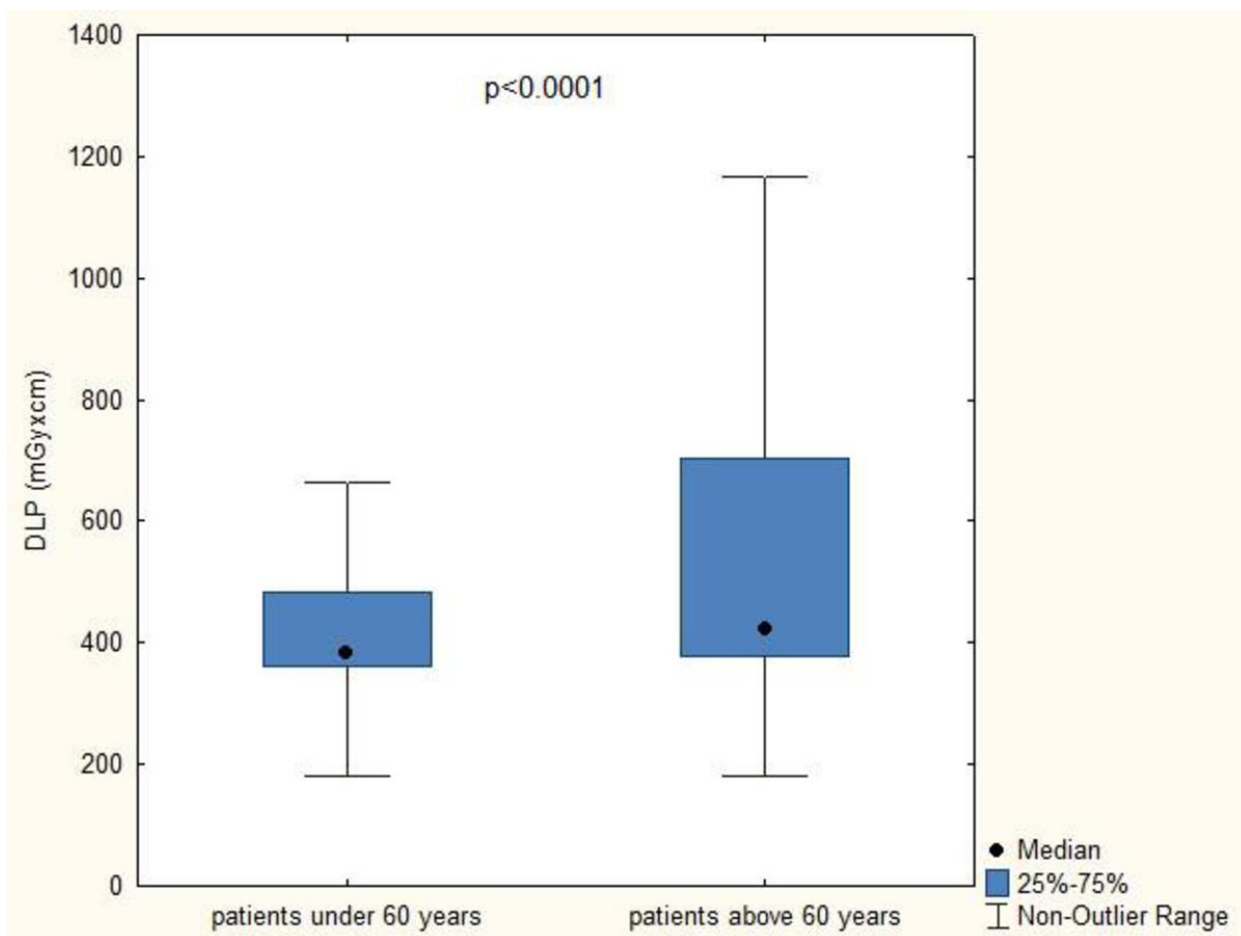


Fig. 6: Radiation doses associated with age, patients under 60 years versus patients above 60 years (382 [360-484] versus 422 [379-701] mGy x cm).

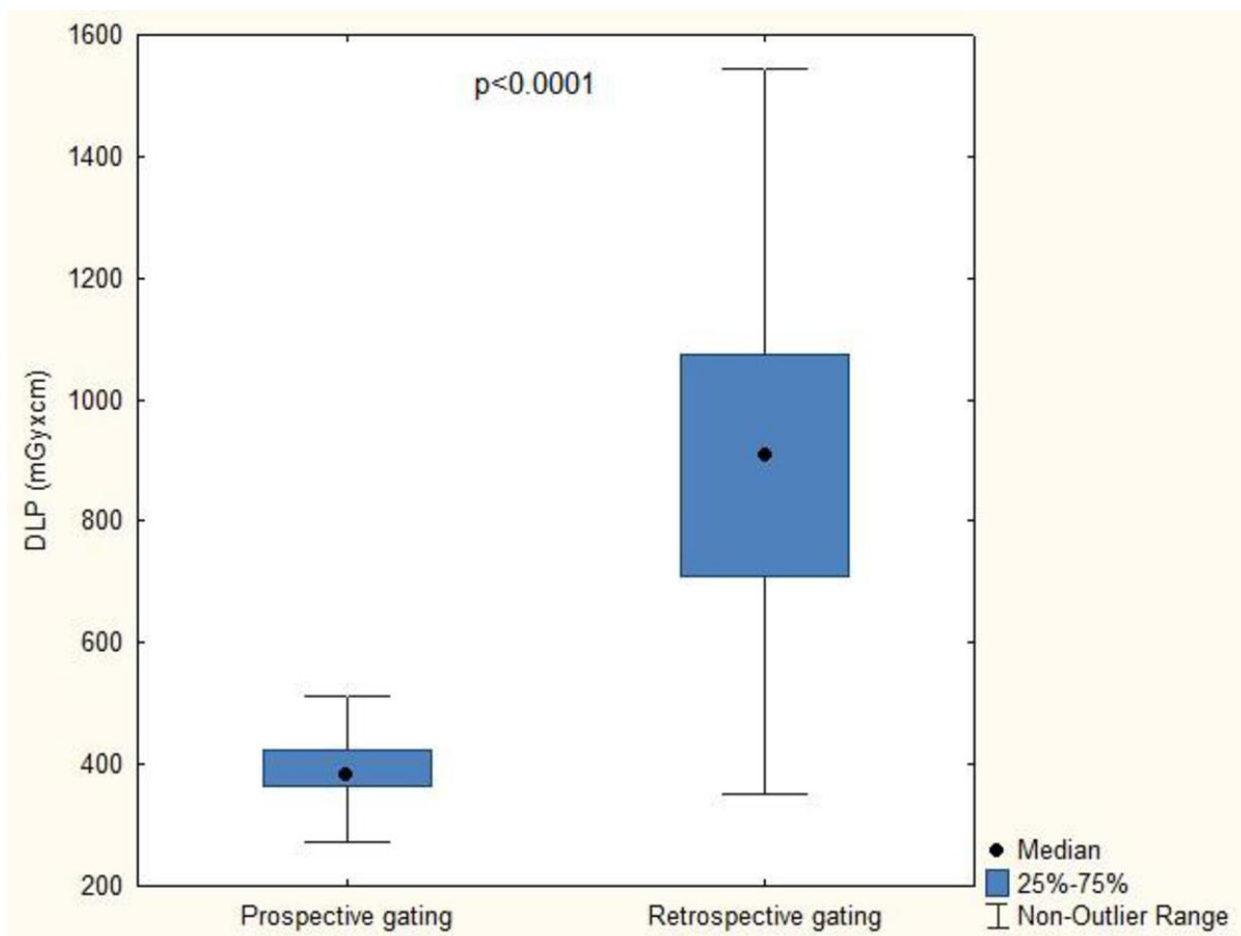


Fig. 7: Radiation doses associated with prospective triggering versus retrospective gating (382 [363-424] versus 907 [710-1073] mGy x cm).

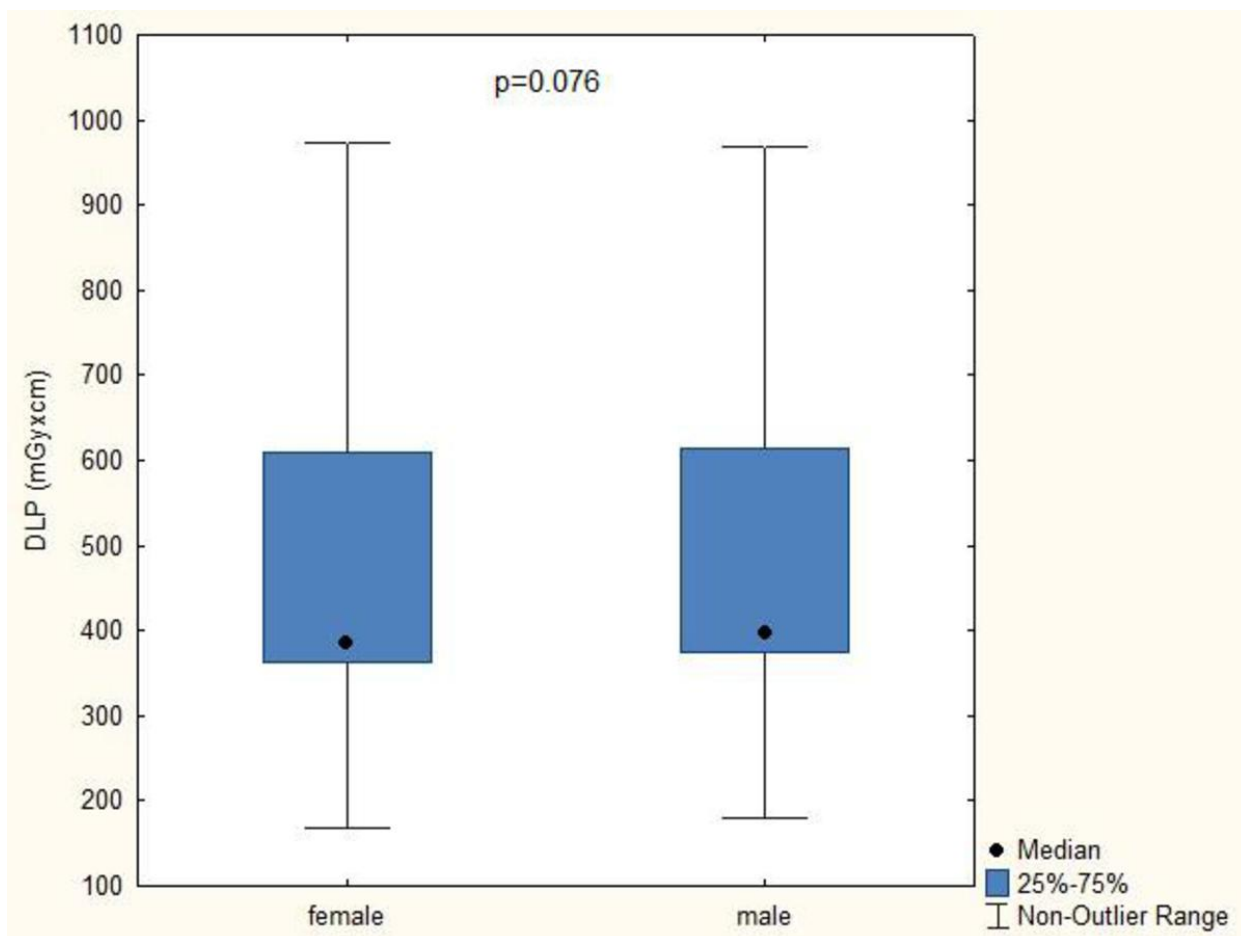


Fig. 8: Radiation doses associated with gender, female versus male (384 [363-609] versus 396 [374-613] mGy x cm, respectively), $p=0.076$.

Conclusion

Our findings demonstrate that 256-CCTA is associated with low radiation doses (median dose 5.5 mSv) in routine clinical practice, which is lower than in other routine CT diagnostic procedures (~50% of abdominal CT and 20% of myocardium perfusion scintigraphy).

At our institute, the independent factors associated with radiation dose reduction were younger age and step-and-shoot scanning mode.

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