

DiSCHARGE

Leiden University Medical Center

DISCHARGE

WP3

EU CT Quality Criteria and
Radiation Exposure



Radiation exposure in CT

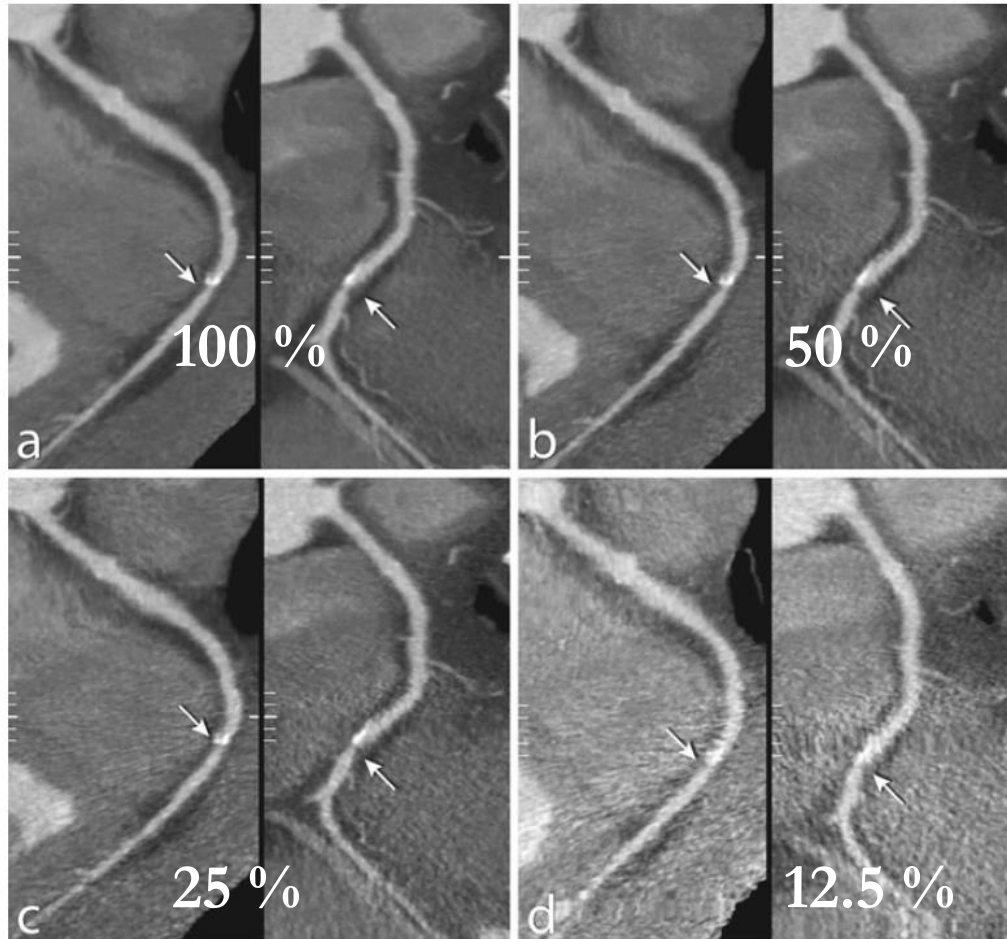
Radiation exposure of patients that undergo CT scans should be justified and should be optimized.

Optimization of CT scans means that there is an optimal balance between radiation exposure and image quality:

- » Just enough radiation exposure to guarantee that the image quality of the CT scan is appropriate for the specific clinical problem of the patient,
- » but not more radiation should be used than necessary.

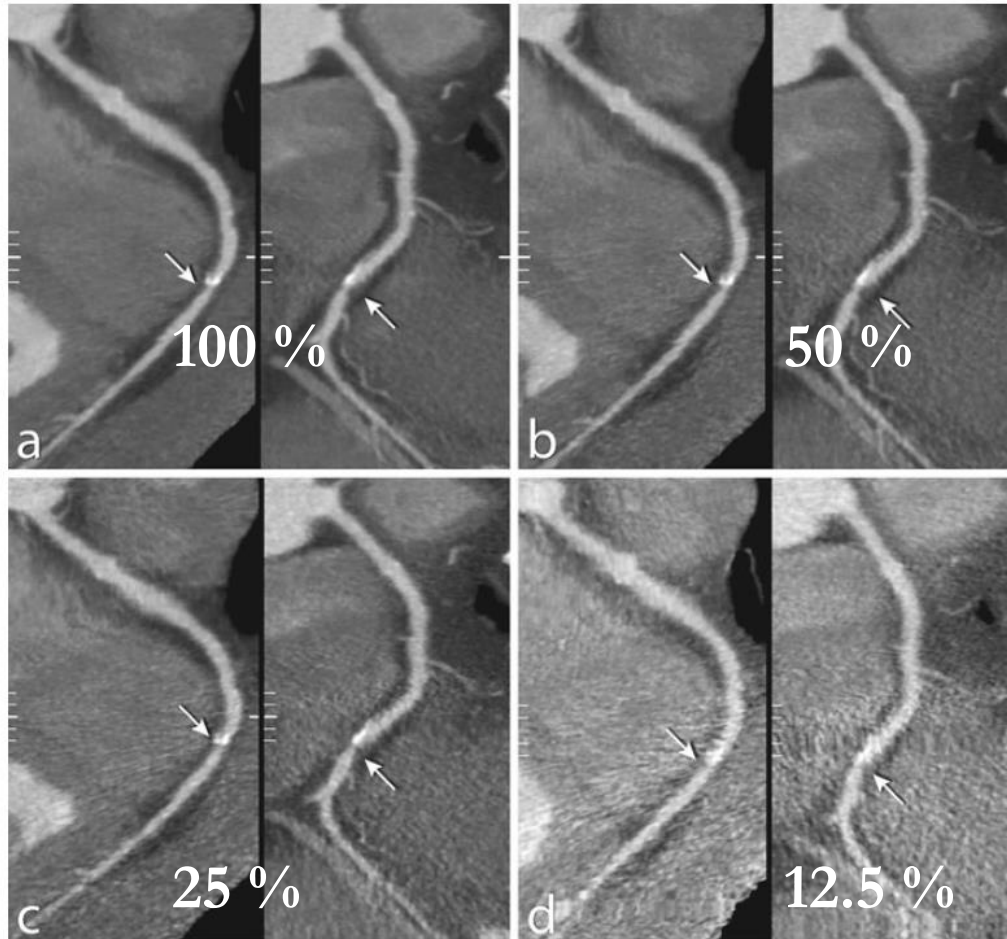
Image quality should always be considered when patient dose and particularly patient dose reduction are being discussed.

Radiation exposure and image quality



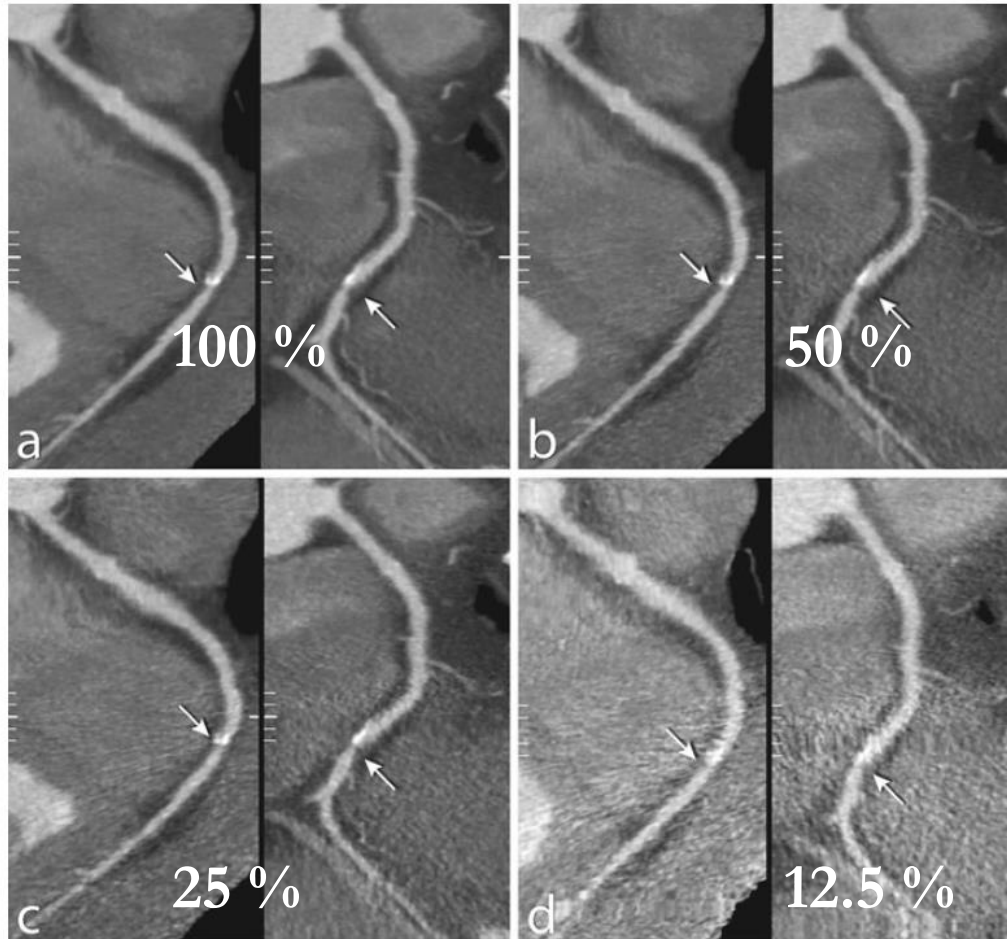
Low dose
simulations of
coronary CT
angiography in a
64-year old male.

Radiation exposure and image quality



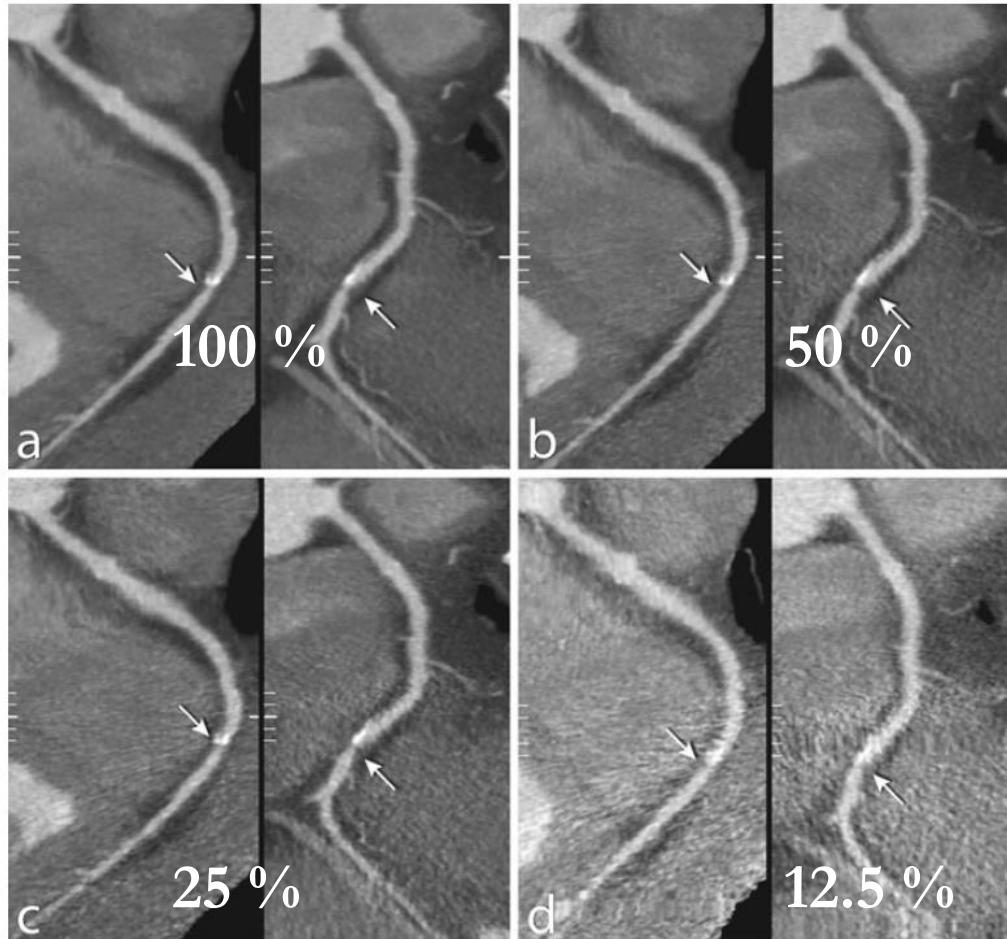
Images show curved multiplanar reconstructions of the right coronary artery for a 100 % dose, b simulated 50 % dose, c 25 and d 12.5 % dose.

Radiation exposure and image quality



A certain minimal amount of radiation is required to perform CT studies that provide appropriate image quality for specific diagnostic problems, for example identification of a stenosis of 50% or more.

Radiation exposure and image quality



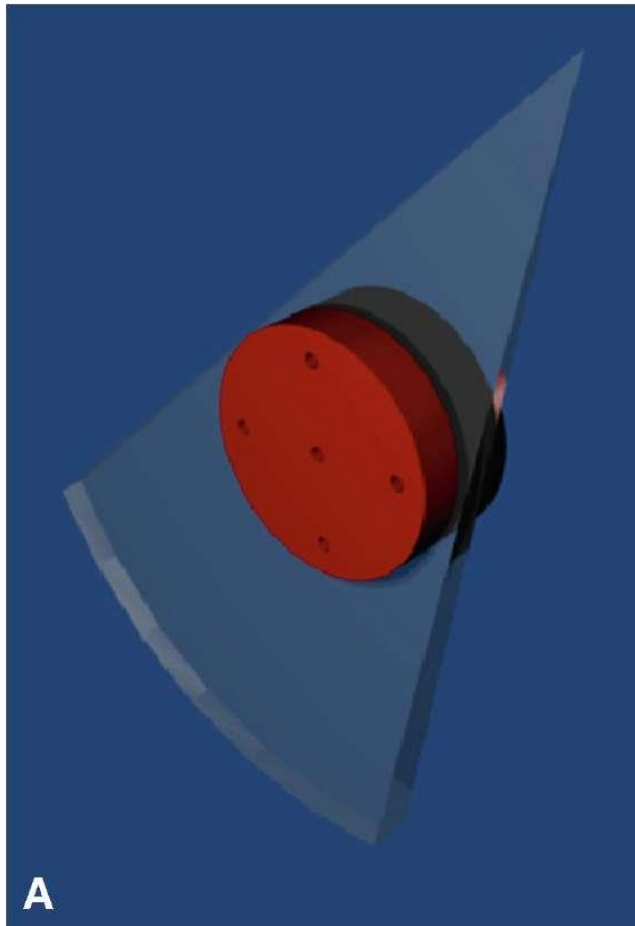
Our study showed that decreased diagnostic quality was already observed for a 50% dose reduction.

Radiation exposure in CT

What are the relevant dose quantities?

- | Computed Tomography Dose Index
- | Dose Length Product
- | Organ and tissue dose
- | Effective dose

Radiation exposure, measurement of CTDI



Radiation exposure, calculation of organ dose and effective dose

ImPACT CT Patient Dosimetry Calculator
Version 1.0 28/08/2009

Scanner Model:
 Manufacturer: Toshiba
 Scanner: Toshiba Aquilion 16
 KV: 120
 Scan Region: Body
 Data Set: MCSET20
 Current Data: MCSET20

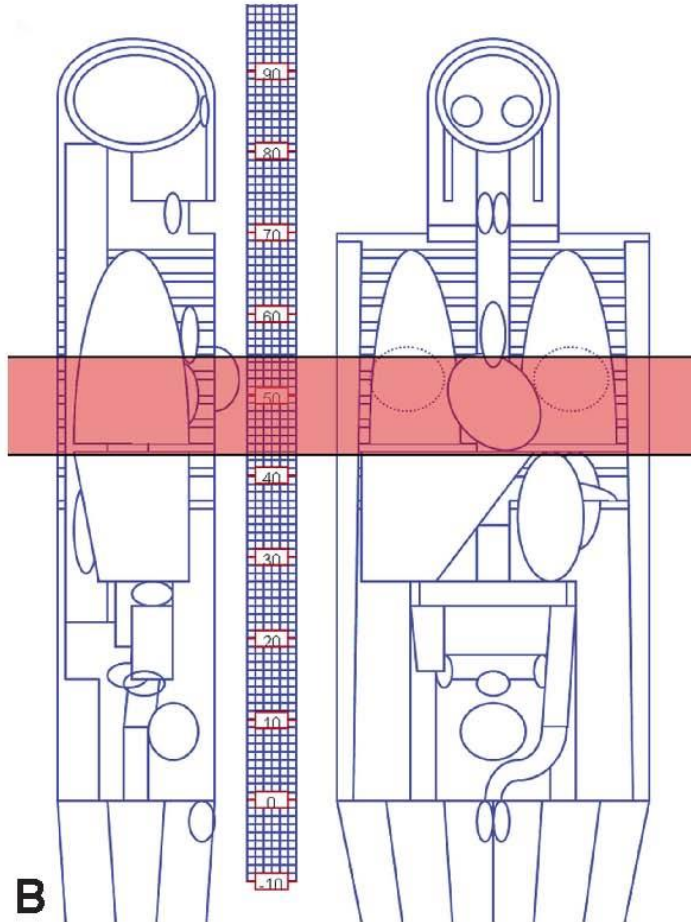
Acquisition Parameters:
 Tube current: 240 mA
 Rotation time: 0.35 s
 Spiral pitch: 0.2
 mAs / Rotation: 84 mAs
 Effective mAs: 420 mAs
 Collimation: 32 (4 x 8) mm
 Rel. CTDI: 0.34 at selected collimation
 CTDI (air): 38.4 mGy/100mAs
 CTDI (soft tissue): 41.1 mGy/100mAs
 nCTDI_w: 12.0 mGy/100mAs

Organ weighting scheme: ICRP 60

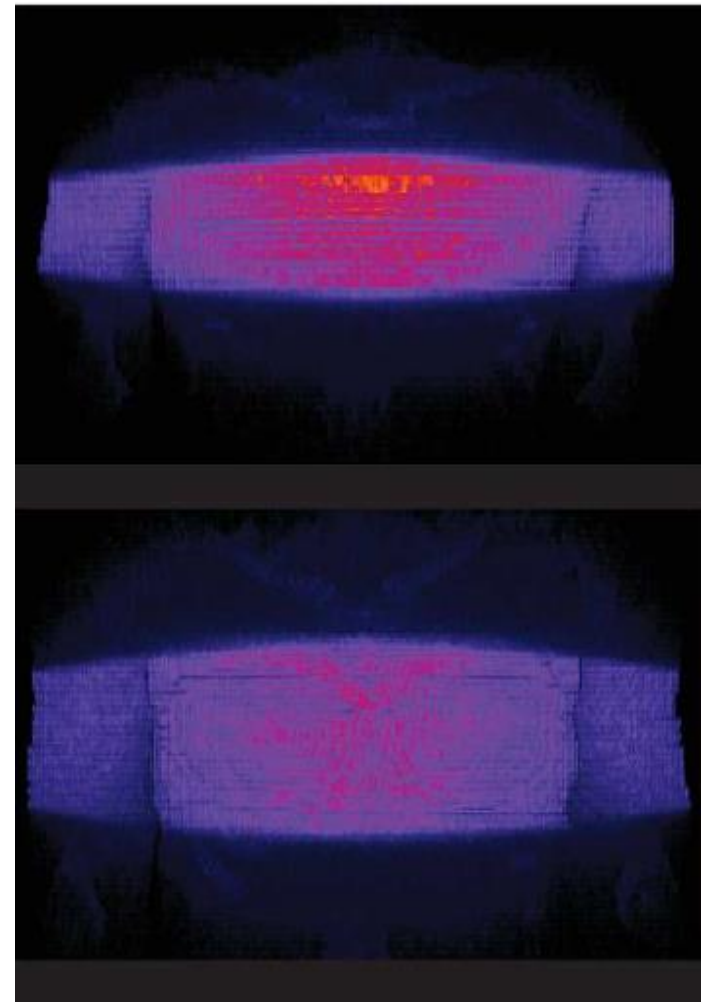
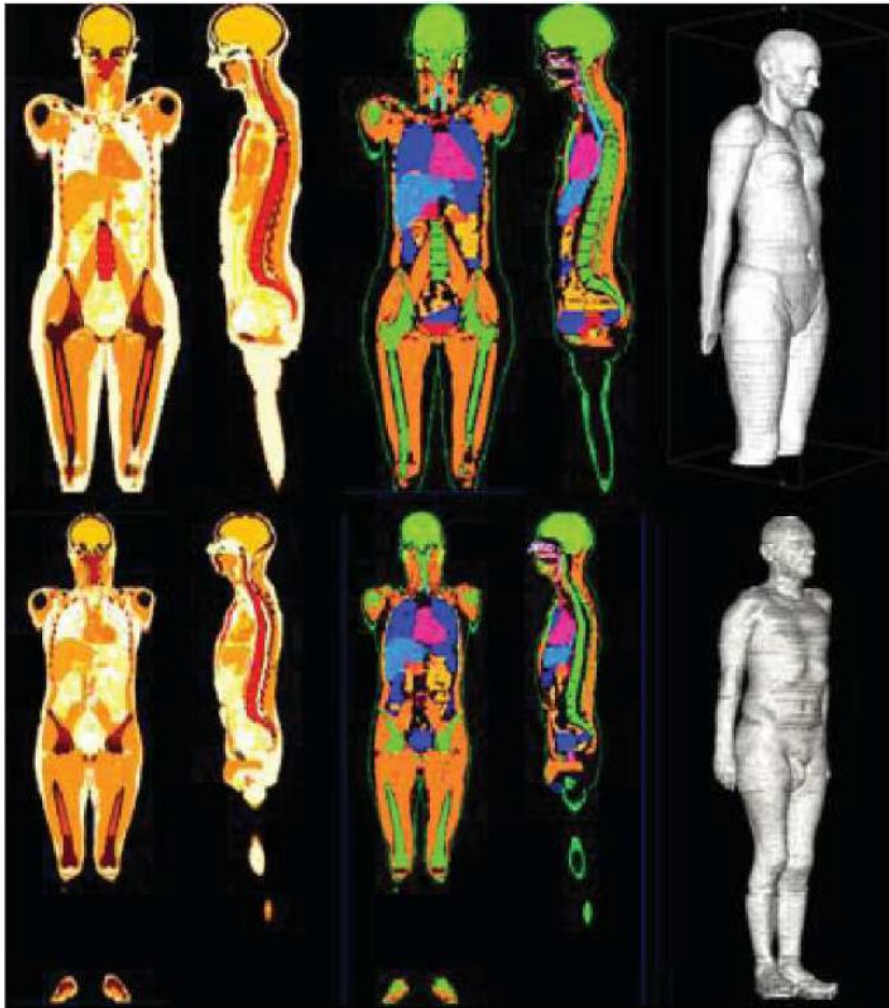
Organ	w _T	H _T (mGy)	w _T ·H _T
Gonads	0.2	0.043	0.0086
Bone Marrow	0.12	8.5	1
Colon	0.12	0.29	0.035
Lung	0.12	45	5.4
Stomach	0.12	6.1	0.73
Bladder	0.05	0.019	0.00095
Breast	0.05	53	2.7
Liver	0.05	9.3	0.46
Oesophagus (Thymus)	0.05	23	1.2
Thyroid	0.05	0.7	0.035
Skin	0.01	6.5	0.065
Bone Surface	0.01	17	0.17
Not Applicable	0	0	0
Not Applicable	0	0	0
Remainder	0.05	5.8	0.28
Not Applicable	0	0	0
Total Effective Dose (mSv)			12

Remainder Organs	H _T (mGy)
Adrenals	12
Small Intestine	0.32
Kidney	2.2
Pancreas	8.9
Spleen	6.7
Thymus	23
Uterus	0.065
Muscle	8
Brain	0.034
Not Applicable	N/A
Not Applicable	N/A
Not Applicable	N/A
Not Applicable	N/A
Other organs of interest	H _T (mGy)
Eye lenses	0.11
Testes	0.0012
Ovaries	0.085
Uterus	0.065
Prostate	0.019

Scan Description / Comments



Computer simulations



The effective dose according to ICRP 103 and k-factors for the coronary CTA

Dosimetry	Effective dose mSv	k-factor mSv/mGy.cm
This study		
<i>Female (≤ 65 bpm)</i>	7.2	0.041
<i>Male (≤ 65 bpm)</i>	3.0	0.016
Average (≤ 65 bpm)	5.1	0.028
Based on software		
ImPACT (21)	4.2	0.023
Based on k-factor		
EC (17)	2.6 *)	0.014
Deak et al. (15)	2.7	0.0145
Seguchi et al. (20)	4.1	0.022
Huda et al. (16)	4.8	0.026
Gosling et al. (19)	5.2	0.028
Einstein et al. (18)	5.4	0.029
Geleijns et al. (10)	5.6	0.030

*) Effective dose calculation based on ICRP 60.

Typical equivalent organ doses (mGy) for different acquisition techniques

	Retrospective gated recon.		Pros.trig.	Ultra low dose
	No TCM	With TCM		
Breast	40	32	10	5
Lung	35	28	9	5
Liver	30	24	8	4
Esophagus	25	20	7	3
Stomach	25	20	7	3
Bone surface	20	16	5	3
Red bone marrow	15	12	4	2
Skin	5	4	1	0.7
Colon	1.5	1	0.4	0.2
Bladder	0.1	0.1	0.03	0.01
Ovaries	0.1	0.08	0.03	0.01
Testes	0.01	0.008	0.003	0.001

Typical effective dose exposure values

Conventional coronary angiography

Diagnostic catheterization	8 (4.0-16) mSv
Percutaneous coronary intervention	12 (5.0-20) mSv

Cardiac CT

CT radiography, planscan	0.05 (0.02-0.10) mSv
Bolus tracking	0.15 (0.10-0.20) mSv
Calcium scoring	2 (1.0-2.0) mSv

Coronary CTA

Retrospectively ECG-gated reconstruction, no TCM	15 (10.0-20.0) mSv
Retrospectively ECG-gated reconstruction, TCM	12 (5.0-15.0) mSv
Prospectively ECG-triggered axial acquisition	4 (2.0-8.0) mSv
Ultra-low-dose (volumetric CT, fast dual-source CT)	< 2.0 mSv

TCM = tube current modulation

Typical effective dose exposure values

Chest radiography

PA chest radiograph	0.02 (0.01-0.04) mSv
LAT chest radiograph	0.04 (0.02-0.05) mSv

SPECT, myocardial perfusion

Rest; technetium Tc-99 m tetrofosmin, 500 MBq	3.8 mSv
Stress; technetium Tc-99 m tetrofosmin, 500 MBq	3.5 mSv

PET, myocardial viability

ISF-Fluorodeoxyglucose (FDG), 400 MBq	7.6 mSv
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A trend towards lower radiation exposure

Submillisievert Median Radiation Dose for Coronary Angiography with a Second-Generation 320–Detector Row CT Scanner in 107 Consecutive Patients

The radiation dose was:

Less than 0.5 mSv for 23 of the 107 CCTA examinations (21.5%)

Less than 1 mSv for 58 examinations (54.2%)

Less than 4 mSv for 103 examinations (96.3%)

All studies were of diagnostic quality, with most having excellent image quality.