

# ΠΜΣ ΚΑΡΔΙΑΓΓΕΙΑΚΗ ΑΠΕΙΚΟΝΙΣΗ

Βασικές αρχές αξονικής τομογραφίας καρδιάς.  
Τεχνικές σάρωσης, σκιαγραφικά, artifacts,  
ακτινοπροστασία.

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Επίκουρη Καθηγήτρια Ακτινολογίας  
ΜΕ ΕΞΕΙΔΙΚΕΥΣΗ ΣΤΗΝ ΚΑΡΔΙΑΓΓΕΙΑΚΗ ΑΠΕΙΚΟΝΙΣΗ

Β' Εργαστήριο Ακτινολογίας  
ΕΚΠΑ

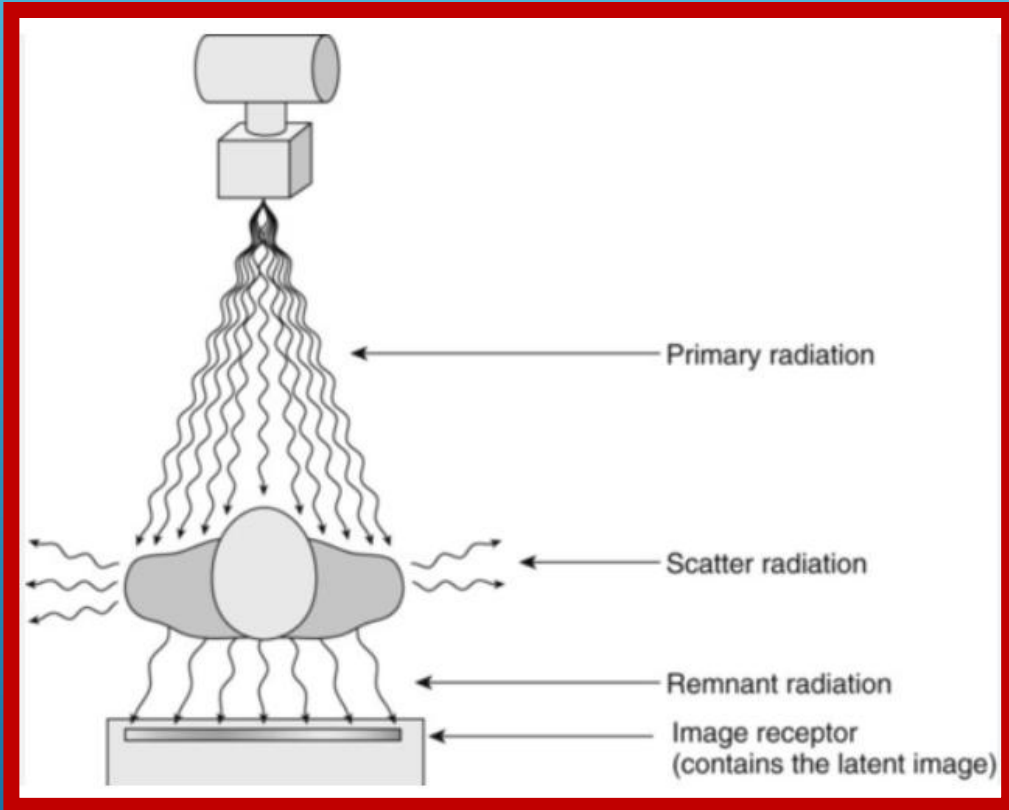
**Ιοντίζουσες** είναι οι **ακτινοβολίες** που μεταφέρουν ενέργεια ικανή να εισχωρήσει στην ύλη, να προκαλέσει ιοντισμό των ατόμων, να διασπάσει βίαια χημικούς δεσμούς και να προκαλέσει βιολογικές βλάβες στον ανθρώπινο οργανισμό.

Οι γνωστότερες ιοντίζουσες ακτινοβολίες είναι οι ακτίνες X που χρησιμοποιούνται ευρέως στην ιατρική, καθώς και οι ακτινοβολίες α, β, και γ που εκπέμπονται από τους ασταθείς πυρήνες ατόμων.



Για σχετικά χαμηλές δόσεις,  
μικρότερες από αυτές που οδηγούν σε άμεσα αποτελέσματα,  
υπάρχει στατιστικά η πιθανότητα μελλοντικής εμφάνισης καρκίνου,  
της οποίας το μέτρο είναι ανάλογο της δόσης.

Ιδιαίτερη σημασία έχουν  
οι βλάβες εκείνες που προκαλούνται στο γενετικό υλικό του  
κυττάρου,  
διότι αυτές συνδέονται τόσο με τη μεταβίβαση κληρονομικών  
ανωμαλιών στους απογόνους όσο και με τη διαδικασία της  
καρκινογένεσης.



When radiation passes through the body, some of it is absorbed.

The x-rays that are not absorbed are used to create the image.

The amount the patient absorbs **contributes to the patient's radiation dose.**

Radiation that passes through the body does not contribute to this dose.

The scientific unit of measurement for whole body radiation dose, called "effective dose," is the **millisievert (mSv).**

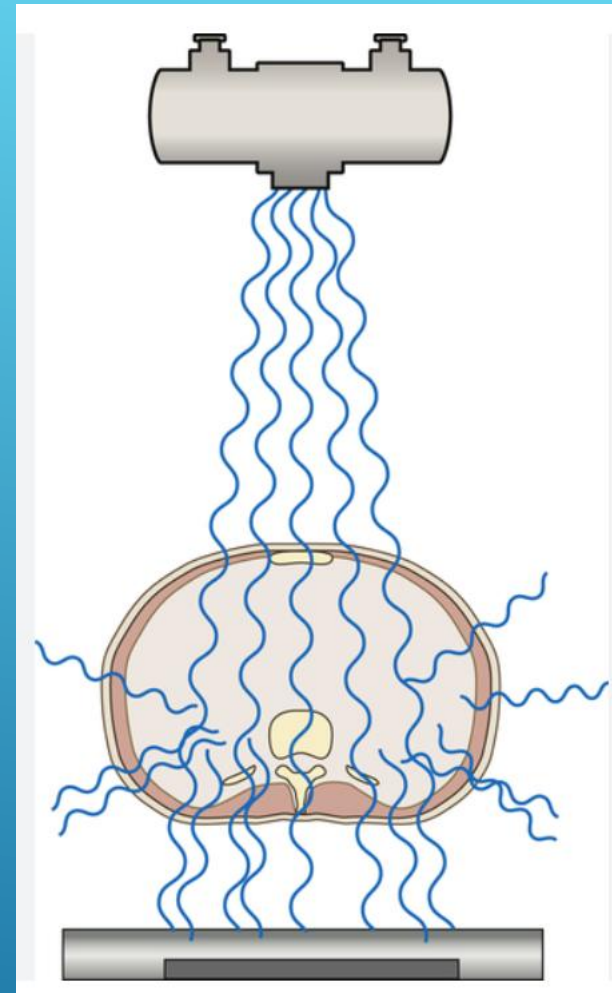
Other radiation dose measurement units include rad, rem, roentgen, sievert, and gray.

Doctors use "effective dose" when they talk about the risk of radiation to the entire body. Risk refers to possible side effects, such as the chance of developing a cancer later in life.

Effective dose considers how sensitive **different tissues** are to radiation.

If you have an x-ray exam that includes tissues or organs that are more sensitive to radiation, your effective dose will be higher.

Effective dose allows your doctor to evaluate your risk and compare it to common, everyday sources of exposure, such as natural background radiation.

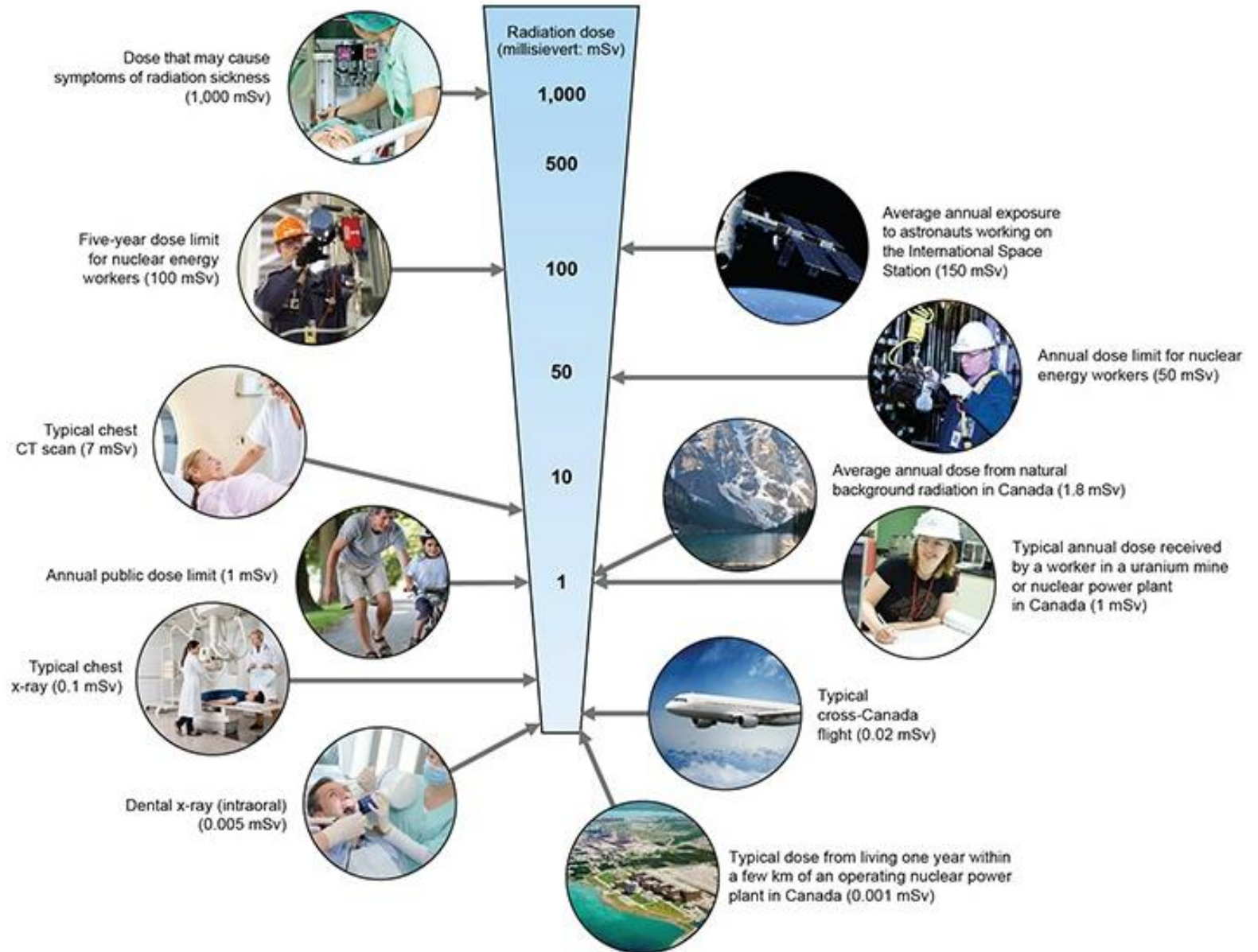


We are exposed to  
natural sources of  
radiation  
all the time.



# Radiation dose examples

Η μέση ενεργός δόση ενός ατόμου που οφείλεται στις τεχνητές και στις φυσικές πηγές ραδιενέργειας του γήινου περιβάλλοντος είναι 0.31 mSv και 2.4 mSv για κάθε χρόνο αντίστοιχα, ενώ η ενεργός δόση που αντιστοιχεί σε μια τυπική ακτινογραφία θώρακος είναι περίπου 0.02 mSv.





As  
Low  
As  
Reasonable  
Achievable

Οι διεθνείς οδηγίες **(ALARA)** συνιστούν την χρήση του πρωτόκολλου με την χαμηλότερη δυνατή δόση ακτινοβολίας, για τον περιορισμό της έκθεσης στην ιοντίζουσα ακτινοβολία στα χαμηλότερα δυνατά επίπεδα, σε συνέπεια με τον αρχικό σκοπό – τη διάγνωση

Η υψηλή διαγνωστική ακρίβεια της αξονικής στεφανιογραφίας (CCTA), ανέδειξε την μέθοδο ως ένα εξαιρετικά πολύτιμο σύμμαχο κατά την διάγνωση της στεφανιαίας νόσου.

Η εξέταση προσφέρει εξαιρετική **χωρική** και **διακριτή** ικανότητα, οδηγώντας στην ευρεία χρήση της.

Αυτό το γεγονός οδήγησε στην ανάγκη εφαρμογής **τεχνικών μείωσης** της χορηγούμενης δόσης ακτινοβολίας, σε μία προσπάθεια να διατηρηθούν τα οφέλη, ελαχιστοποιώντας κατά το δυνατόν όμως, το ρίσκο από την χρήση της ιοντίζοντας ακτινοβολίας.



Η δόση ακτινοβολίας  
κυμαίνεται συνήθως μεταξύ  
**0,5mSv** και **21mSv**.

Η **μεγάλη απόκλιση** των τιμών  
εξαρτάται από το πρωτόκολλο της  
εξέτασης, τις παραμέτρους και τις  
δυνατότητες του αξονικού τομογράφου, τον  
καρδιακό ρυθμό και το body mass index  
(BMI) του ασθενούς.



ESC

European Society  
of Cardiology

European Heart Journal (2018) 39, 3715–3723

doi:10.1093/eurheartj/ehy546

**FASTTRACK CLINICAL RESEARCH**

*Imaging*

## Reduction in radiation exposure in cardiovascular computed tomography imaging: results from the PROspective multicenter registry on radiaTion dose Estimates of cardiac CTanglOgraphy iN daily practice in 2017 (PROTECTION VI)

Thomas J. Stocker<sup>1,2</sup>, Simon Deseive<sup>1,2</sup>, Jonathon Leipsic<sup>3</sup>, Martin Hadamitzky<sup>4</sup>, Marcus Y. Chen<sup>5</sup>, Ronen Rubinshtein<sup>6</sup>, Mathias Heckner<sup>1</sup>, Jeroen J. Bax<sup>7</sup>, Xiang-Ming Fang<sup>8</sup>, Erik Lerkevang Grove<sup>9</sup>, John Lesser<sup>10</sup>, Pál Maurovich-Horvat<sup>11</sup>, James Otton<sup>12</sup>, Sanghoon Shin<sup>13</sup>, Gianluca Pontone<sup>14</sup>, Hugo Marques<sup>15</sup>, Benjamin Chow<sup>16</sup>, Cesar H. Nomura<sup>17</sup>, Ramzi Tabbalat<sup>18</sup>, Axel Schmermund<sup>19</sup>, Joon-Won Kang<sup>20</sup>, Christopher Naoum<sup>21</sup>, Melany Atkins<sup>22</sup>, Eugenio Martuscelli<sup>23</sup>, Steffen Massberg<sup>1,2</sup>, and Jörg Hausleiter<sup>1,2\*</sup>; for the PROTECTION VI investigators<sup>†</sup>

## Methods and results

61 hospitals from 32 countries prospectively enrolled 4502 patients undergoing cardiac CTA during one calendar month in 2017.

Computed tomography angiography scan data and images were analyzed in a central core lab and compared with a similar dose survey performed in 2007.

Several white lines of varying lengths and orientations are positioned in the bottom right corner of the slide, serving as a decorative element.

**Table 2** Scan characteristics for coronary CT angiographies

|                                    | 2007 dose survey<br>(1611 patients) | 2017 dose survey<br>(4006 patients) | P-value |
|------------------------------------|-------------------------------------|-------------------------------------|---------|
| Scan length (mm)                   | 131 (118–144)                       | 137 (125–157)                       | <0.001  |
| Total DLP (mGy*cm)                 | NA                                  | 246 (153–402)                       | NA      |
| CTDIvol <sub>CTA</sub> (mGy)       | 54 (38–74)                          | 14 (8–24)                           | <0.001  |
| DLP <sub>CTA</sub> (mGy*cm)        | 885 (560–1239)                      | 195 (110–338)                       | <0.001  |
| Regional DLP for coronary CTA only |                                     |                                     |         |
| Europe (mGy*cm)                    | 814 (537–1151)                      | 176 (93–312)                        | <0.001  |
| North America (mGy*cm)             | 993 (292–1343)                      | 199 (124–340)                       | <0.001  |
| Latin and South America (mGy*cm)   | 1556 (711–1932)                     | 295 (189–624)                       | <0.001  |
| Middle East (mGy*cm)               | 1799 (1482–2138)                    | 244 (132–400)                       | <0.001  |
| East Asia and Australia (mGy*cm)   | 940 (599–1130)                      | 169 (96–276)                        | <0.001  |

A **37-fold variability** in median DLP was observed between the hospitals with lowest and highest DLP (range of median DLP 57–2090 mGy\*cm).

Independent predictors for radiation dose of coronary CTA were: body weight, heart rate, sinus rhythm, tube voltage, iterative image reconstruction, and the selection of scan protocols.



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Reasonable  
Achievable

Οι διεθνείς οδηγίες **(ALARA)** συνιστούν την χρήση του πρωτόκολλου την χαμηλότερη δυνατή δόση ακτινοβολίας, για τον περιορισμό της έκθεσης στην ιοντίζουσα ακτινοβολία στα χαμηλότερα δυνατά επίπεδα, σε συνέπεια όμως με τον αρχικό σκοπό, που είναι η **διάγνωση**.

Η υψηλή διαγνωστική ακρίβεια της αξονικής στεφανιογραφίας (CCTA), ανέδειξε την μέθοδο ως ένα εξαιρετικά πολύτιμο σύμμαχο κατά την διάγνωση της στεφανιαίας νόσου.

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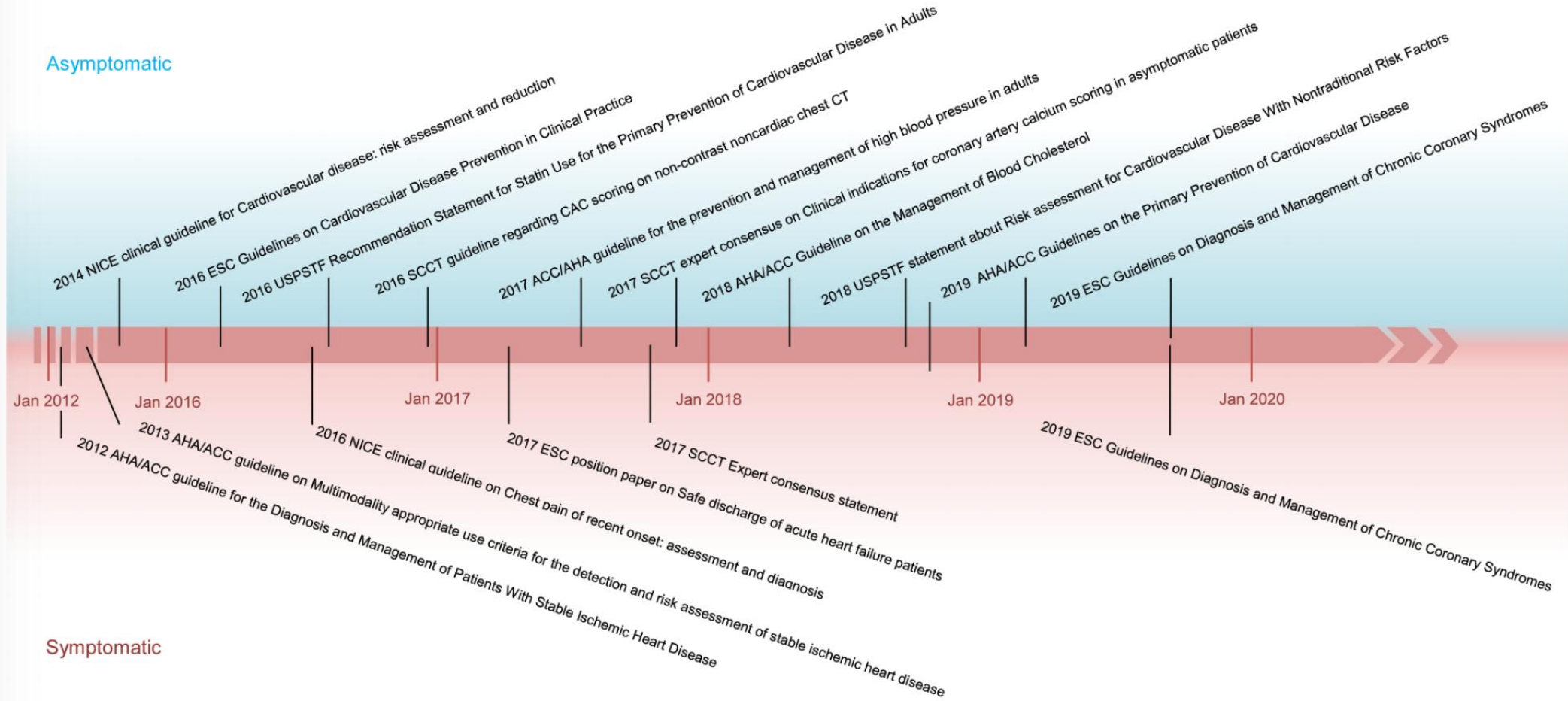
διατηρηθούν τα οφέλη,  
ελαχιστοποιώντας κατά το δυνατόν όμως,  
το ρίσκο από την χρήση της ιοντίζοντας ακτινοβολίας.

# SCANNING TECHNIQUES IN CT CORONARY ANGIOGRAPHY

- DEDICATED SCANS

1. TAVI
2. PLANING ELECTROPHYSIOLOGICAL PROCEDURE
3. TRIPLE RULE OUT
4. RV ASSESSMENT
5. CONGENITAL/ADULT CONGENITAL

Asymptomatic





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## SCCT Guidelines

# SCCT guidelines for the interpretation and reporting of coronary CT angiography of the Society of Cardiovascular Computed Tomography Guidelines Committee

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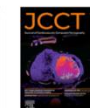


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## Guideline

# 2020 SCCT Guideline for Training Cardiology and Radiology Trainees as Independent Practitioners (Level II) and Advanced Practitioners (Level III) in Cardiovascular Computed Tomography: A Statement from the Society of Cardiovascular Computed Tomography

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## ABSTRACT

Cardiovascular computed tomography (CCT) is a well-validated non-invasive imaging tool with an ever-expanding array of applications beyond the assessment of coronary artery disease. These include the evaluation of structural heart diseases, congenital heart diseases, peri-procedural electrophysiology applications, and the functional evaluation of ischemia. This breadth requires a robust and diverse training curriculum to ensure graduates of CCT training programs meet minimum competency standards for independent CCT interpretation. This statement from the Society of Cardiovascular Computed Tomography aims to supplement existing societal training guidelines by providing a curriculum and competency framework to inform the development of a comprehensive, integrated training experience for cardiology and radiology trainees in CCT.

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Journal of Cardiovascular Computed Tomography



# Guideline for the acquisition of coronary CT angiography: A report of the Society of Cardiovascular Computed Tomography Guidelines Committee for Cardiovascular Imaging

Maroules<sup>a</sup>, Michael Cheezum<sup>c</sup>, Irfan<sup>l</sup>, Chris Naoum<sup>g</sup>, Ron Blankstein<sup>k</sup>, Todd Villines<sup>j</sup>

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<sup>c</sup> Tel Aviv, Israel

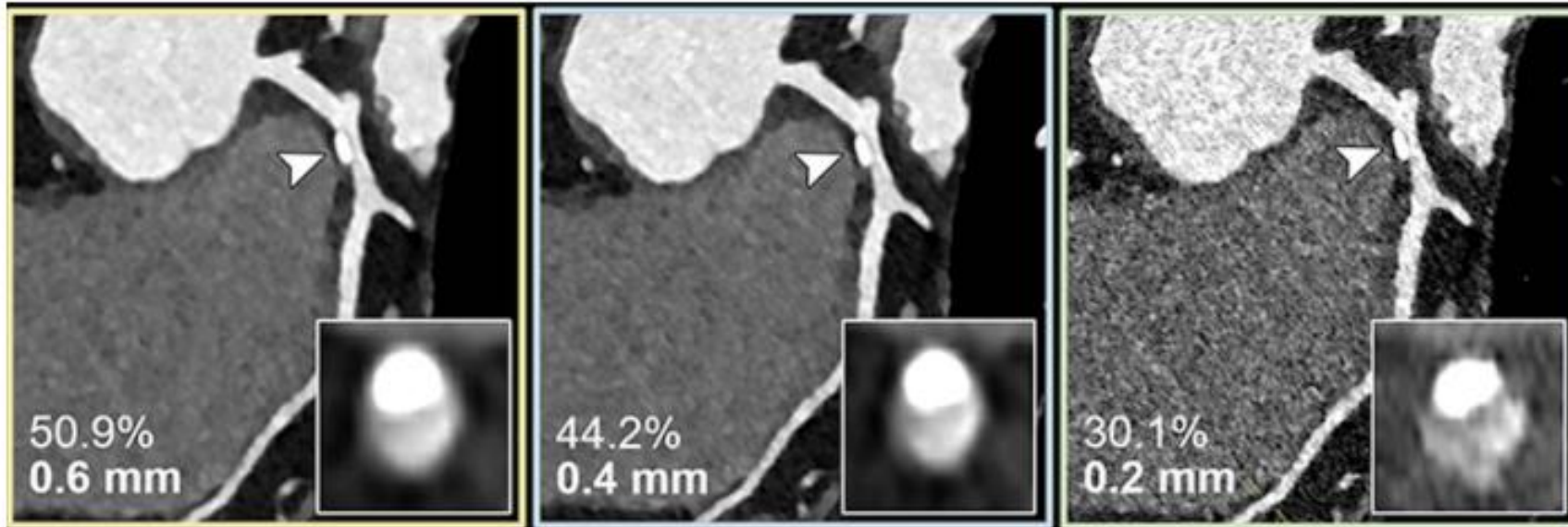
<sup>d</sup> United States

Technological advancements in acquisition techniques as well as a growing body of evidence on the impact of CT on patient performance of coronary computed tomography angiography (coronary CT angiography) have led the Society of Cardiovascular Computed Tomography Guidelines Committee to produce this guideline. The guideline is intended to provide standards meant to ensure reliable practice methods and quality of care. The guideline is intended to be used in conjunction with the Society of Cardiovascular Computed Tomography Guidelines for the Interpretation of Coronary CT Angiography (1). The guideline is published separately (2). The Society of Cardiovascular Computed Tomography Guidelines Committee ensures compliance with all applicable laws and regulations. A declaration of conflict of interest by all authors and reviewers for the purpose of this guideline is provided. Journal of Cardiovascular Computed Tomography. Published by Elsevier Inc. All rights reserved.

# ▶ PHOTON COUNTING CT



## Photon-Counting CT Improves Coronary Artery Disease Assessment



*Coronary CT angiography for the suspected progression of known coronary artery disease in a 56-year-old female patient. Curved multiplanar reconstructions with 0.6-mm (yellow outline), 0.4-mm (blue outline), and 0.2-mm (green outline) section thickness show the respective calcified plaque (arrowheads) and coronary stenosis (inset images). The reduced section thickness leads to less calcium blooming and therefore a less severe assessment of percentage of coronary stenosis in this patient.*

<https://doi.org/10.1148/radiol.231956> © RSNA 2024

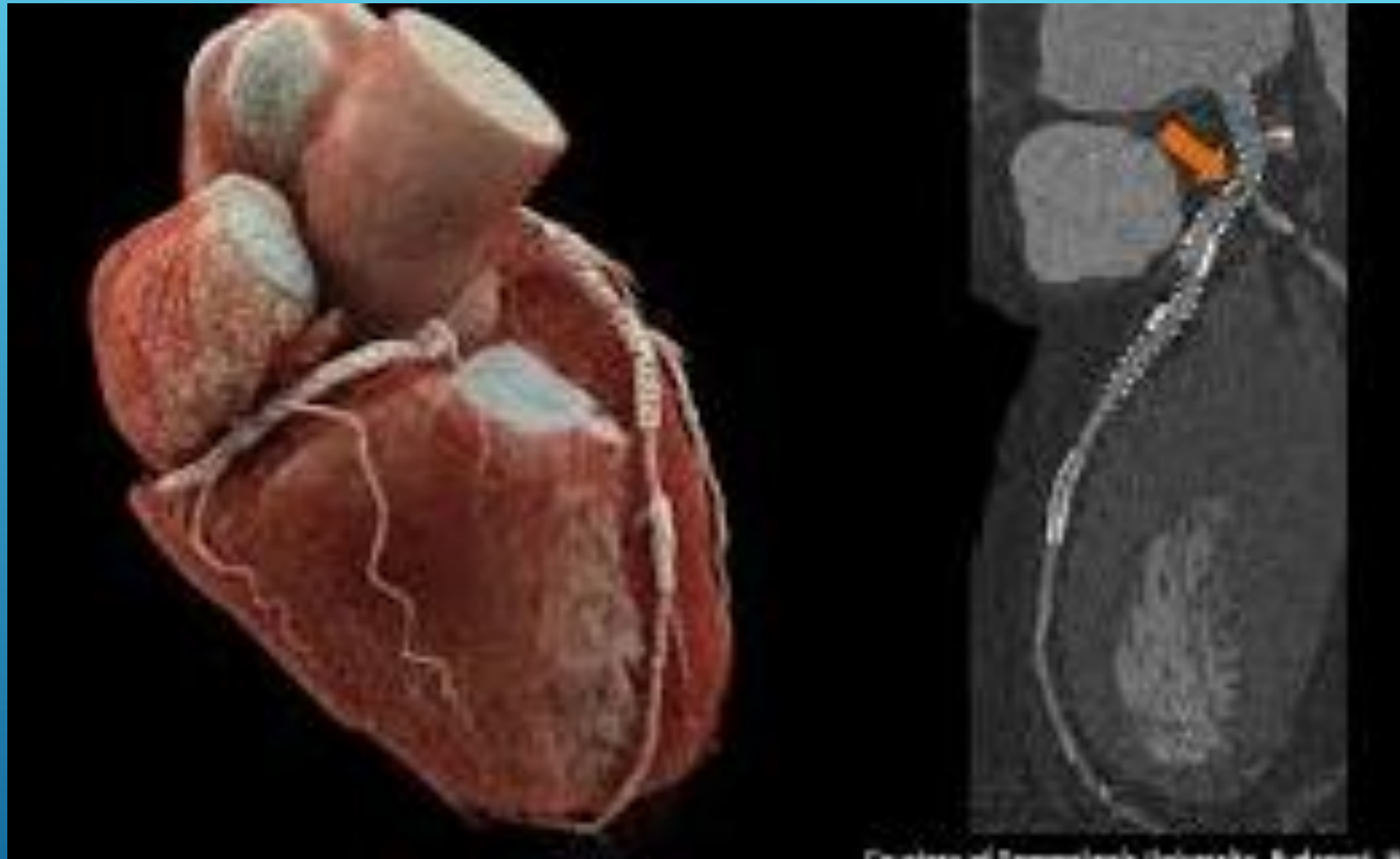


Figure 1. Catheter placement in the heart.

Photon-counting detectors provide significantly better, lower-noise images when examining obese patients and for low-dose scans,

thus opening up the possibility of reducing the radiation dose even further than today.



EUROPEAN  
SOCIETY OF  
CARDIOVASCULAR  
RADIOLOGY

SOCIETY

MEMBERSHIP

CONGRESS 2023

EDUCATION

DIPLOMA

PUBLICATIONS

## HOW-I-DO-IT

Short and expert-prepared guidelines for your daily practice:

### Coronary CTA in patients with chronic coronary syndrome

Casper Muhl, Francesco Secchi, Dominika Suchá

Click [here](#) to access the document.



# TEAMWORK

## Must Make Team with Radiographer, Nurses and Secretaries

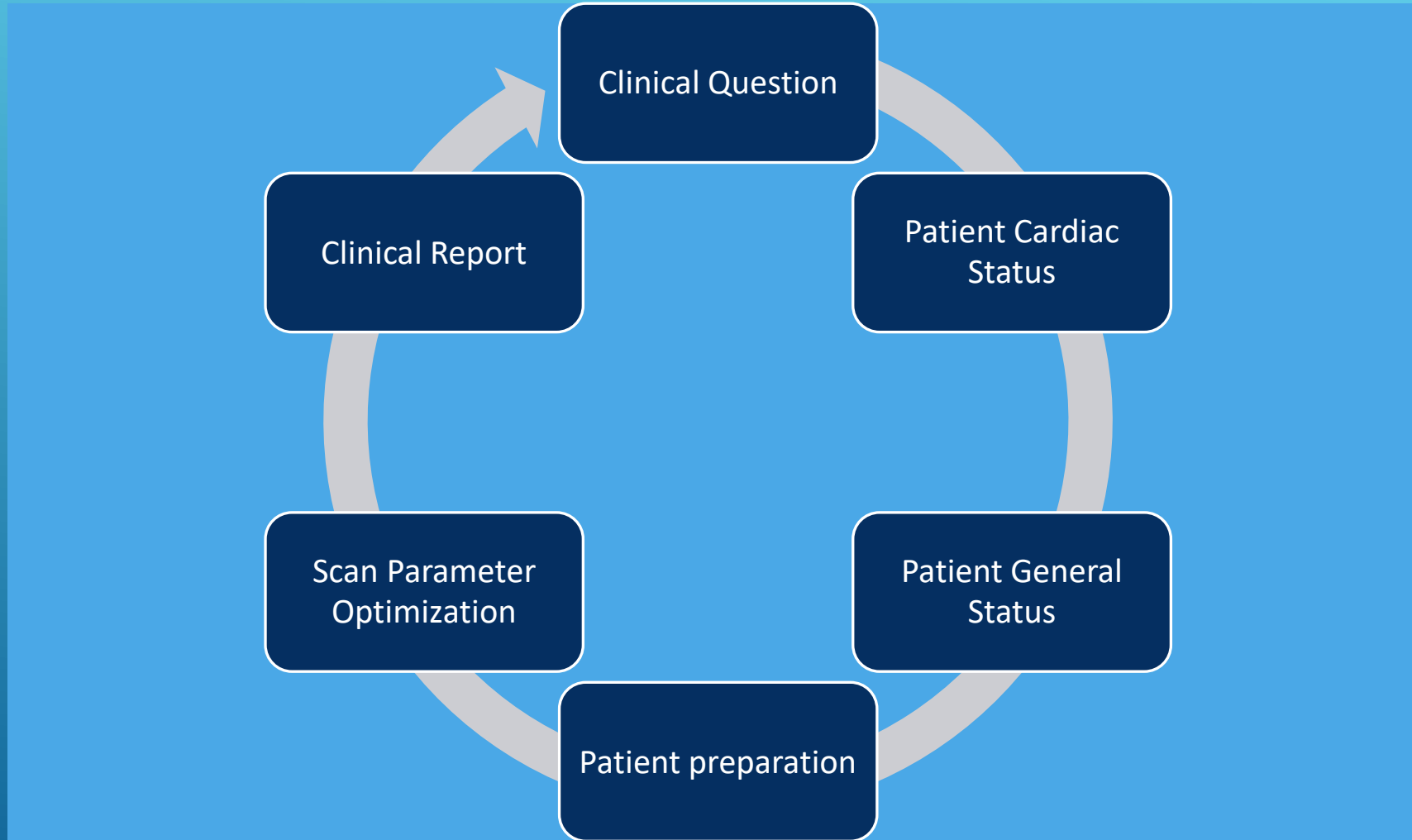
- ▶ Choose from Senior staff
  - ▶ Training (courses, Life Support, Communication Skills)
  - ▶ Allocate Roles
  - ▶ Motivate
  - ▶ Audit Service Regularly
- 
- A series of three parallel white diagonal lines on the right side of the slide, pointing towards the bottom right corner.

# TEAMWORK

## Be a Team with Referral Cardiologists

- ▶ The Reporter has to guide: Bradycardiac Pre-medication  
Renal Safety  
Allergy
- ▶ Clinical Communication Based on Guidelines
- ▶ Be familiar with Therapy Strategies
- ▶ Use CAD-RADS

# A SUCCESSFUL CARDIAC CTCA SERVICE



## LEARNING GOALS:

- ❑ ASSESS PATIENT
  - ❑ SCANNING TECHNIQUES
  - ❑ ASSESS IMAGE QUALITY- ARTIFACTS
- 
- A series of three parallel white diagonal lines extending from the bottom right towards the top right of the slide.

# CARDIAC STATUS

1. Risk Factors
  2. Symptom
  3. Previous Cardiology History
  4. Heart Rate/ Rhythm
  5. Procedures
  6. Medications
- 
- Three parallel white lines of varying lengths are positioned diagonally in the bottom right corner of the slide, pointing towards the top right.

# ASSESS PATIENT

- RISK FACTORS

FAMILY HISTORY

DIABETES MELLITUS

DYSLIPIDEMIA

ARTERIAL HYPERTENSION

SMOCKING

OBESITY

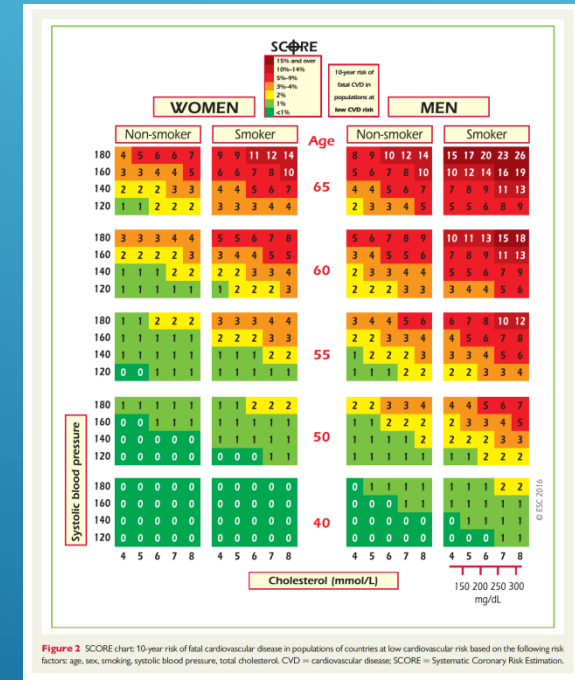
KNOW CAD – STENT CABG

## PATIENT RISK STRATIFICATION

**Table 4 Cardiovascular risk categories**

|                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|-----------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Very-high-risk</b> | People with any of the following:<br>Documented ASCVD, either clinical or unequivocal on imaging. Documented ASCVD includes previous ACS (MI or unstable angina), stable angina, coronary revascularization (PCI, CABG), and other arterial revascularization procedures, stroke and TIA, and peripheral arterial disease. Unequivocally documented ASCVD on imaging includes those findings that are known to be predictive of clinical events, such as significant plaque on coronary angiography or CT scan (multivessel coronary disease with two major epicardial arteries having >50% stenosis), or on carotid ultrasound.<br>DM with target organ damage, <sup>a</sup> or at least three major risk factors, or early onset of T1DM of long duration (>20 years).<br>Severe CKD (eGFR <30 mL/min/1.73 m <sup>2</sup> ).<br>A calculated SCORE ≥10% for 10-year risk of fatal CVD.<br>FH with ASCVD or with another major risk factor. |
| <b>High-risk</b>      | People with:<br>Markedly elevated single risk factors, in particular TC >8 mmol/L (>310 mg/dL), LDL-C >4.9 mmol/L (>190 mg/dL), or BP ≥180/110 mmHg.<br>Patients with FH without other major risk factors.<br>Patients with DM without target organ damage, <sup>a</sup> with DM duration ≥10 years or another additional risk factor.<br>Moderate CKD (eGFR 30–59 mL/min/1.73 m <sup>2</sup> ).<br>A calculated SCORE ≥5% and <10% for 10-year risk of fatal CVD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Moderate-risk</b>  | Young patients (T1DM <35 years; T2DM <50 years) with DM duration <10 years, without other risk factors. Calculated SCORE ≥1% and <5% for 10-year risk of fatal CVD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Low-risk</b>       | Calculated SCORE <1% for 10-year risk of fatal CVD.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

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**Figure 2** SCORE chart: 10-year risk of fatal cardiovascular disease in populations of countries at low cardiovascular risk based on the following risk factors: age, sex, smoking, systolic blood pressure, total cholesterol. CVD = cardiovascular disease; SCORE = Systematic Coronary Risk Estimation.

# ASSESS PATIENT

- SYMPTOMS

ASYMPTOMATIC

ATYPICAL CHEST PAIN

ANGINA (TYPICAL OR ATYPICAL)

DYSPNEA

## EVENT RISK STRATIFICATION

**Table 5** Pre-test probabilities of obstructive coronary artery disease in 15 815 symptomatic patients according to age, sex, and the nature of symptoms in a pooled analysis<sup>6,4</sup> of contemporary data<sup>7,8,62</sup>

| Age   | Typical |       | Atypical |       | Non-anginal |       | Dyspnoea <sup>a</sup> |       |
|-------|---------|-------|----------|-------|-------------|-------|-----------------------|-------|
|       | Men     | Women | Men      | Women | Men         | Women | Men                   | Women |
| 30–39 | 3%      | 5%    | 4%       | 3%    | 1%          | 1%    | 0%                    | 3%    |
| 40–49 | 22%     | 10%   | 10%      | 6%    | 3%          | 2%    | 12%                   | 3%    |
| 50–59 | 32%     | 13%   | 17%      | 6%    | 11%         | 3%    | 20%                   | 9%    |
| 60–69 | 44%     | 16%   | 26%      | 11%   | 22%         | 6%    | 27%                   | 14%   |
| 70+   | 52%     | 27%   | 34%      | 19%   | 24%         | 10%   | 32%                   | 12%   |

CAD = coronary artery disease; PTP = pre-test probability.

<sup>a</sup>In addition to the classic Diamond and Forrester classes,<sup>59</sup> patients with dyspnoea only or dyspnoea as the primary symptom are included. The regions shaded dark green denote the groups in which non-invasive testing is most beneficial (PTP >15%). The regions shaded light green denote the groups with PTPs of CAD between 5–15%, in which testing for diagnosis may be considered after assessing the overall clinical likelihood based on the modifiers of PTPs presented in Figure 3.

## **CONTRAINDICATIONS**

- history of severe anaphylactic reaction to iodinated contrast
- inability to cooperate
- hemodynamic instability
- decompensated heart failure
- acute myocardial infarction (coronary CTA may be indicated in selected patients with acute coronary syndrome)
- renal impairment (specific thresholds are deferred to individual performing institutions)
- manifest hyperthyroidism (only in specific situations)

## Relative contraindications

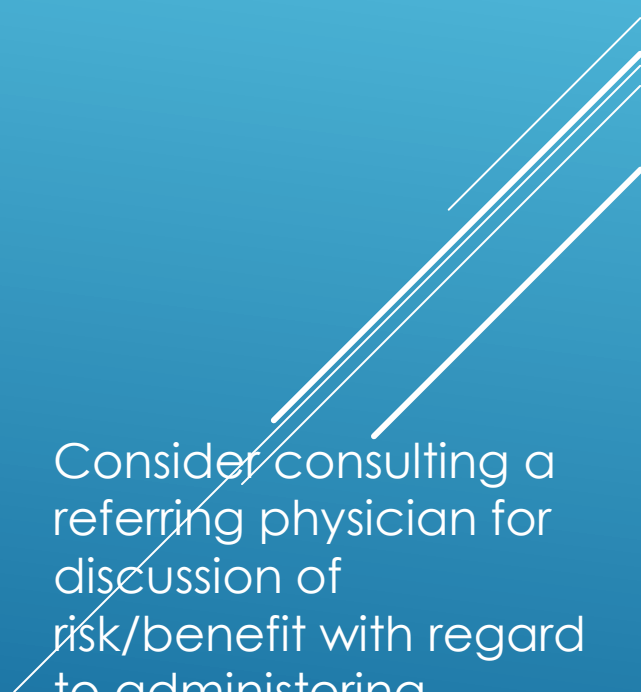
- pregnancy
- inability to tolerate heart rate-slowing medications or nitroglycerin

- Check contra-indications

- for beta-blockers  
(severe asthma/COPD, hypotension, high degree atrioventricular block) and
  - nitroglycerin (hypotension, recent use of phosphodiesterase inhibitors, severe aortic stenosis)

- If a contraindication to beta-blockers is present, CTA can be done with a different protocol

- tachycardia and/or arrhythmia



Consider consulting a referring physician for discussion of risk/benefit with regard to administering medication.

# ASSESS PATIENT

- SYMPTOM
- RISK FACTORS
- RENAL STATUS
- ALLERGY
- BODY HABITUS
- HEART RATE / BLOOD I
- RHYTHM



# PATIENT PREPARATION

1. **EXPLAIN PROCEDURE**
  2. Preparation for Contrast administration
  3. Heart Rate and Rhythm Control
- 
- Three parallel white diagonal lines are located in the bottom right corner of the slide, extending from the middle of the right edge towards the bottom left.

## CONSENT AND PREPROCEDURAL PATIENT CARE



A detailed explanation of the procedure will be given to the patient, which is important to ensure full understanding and cooperation. The explanation will include possible risks and complications of the procedure, so that the patient is fully informed before signing the consent

## What to explain:

CT exams are generally painless, fast, and easy.

Multidetector CT reduces the amount of time that the patient needs to **lie still**.

Though the scan is painless, may be some discomfort from remaining still for several minutes or from placement of an IV. If you have a hard time staying still, are very nervous, anxious, or in pain, you may find a CT exam stressful. The technologist or nurse, under the direction of a doctor, may offer you some medication to help you tolerate the CT exam.

# PATIENT PREPARATION

1. Explain Procedure
  2. PREPARATION FOR CONTRAST ADMINISTRATION
  3. Heart Rate and Rhythm Control
- 
- Three parallel white lines of varying lengths are positioned diagonally in the bottom right corner of the slide, pointing towards the top right.

## What to explain:

If the exam uses iodinated contrast material, your doctor will screen you for chronic or acute kidney disease.

The doctor may administer contrast material intravenously (by vein), so you will feel a pin prick when the technologist or nurse inserts the needle into your vein.

- You may feel warm or flushed as the contrast is injected.
- You also may have a metallic taste in your mouth.
- You may feel a need to urinate.

However, these are only side effects of the contrast injection, and they subside quickly.

## What to explain:

When you enter the CT scanner, you may see special light lines projected onto your body. These lines help ensure that you are in the correct position on the exam table. With modern CT scanners, you may hear slight buzzing, clicking and whirring sounds. These occur as the CT scanner's internal parts, not usually visible to you, revolve around you during the imaging process.

You will be alone in the exam room during the CT scan, unless there are special circumstances. For example, sometimes a parent wearing a lead shield may stay in the room with their child. However, the technologist will always be able to see, hear and speak with you through a built-in intercom system.

After a CT exam, the nurse will remove your intravenous line. They will cover the tiny hole made by the needle with a small dressing. You can return to your normal activities immediately.

# ASSESS PATIENT

## RENAL FUNCTION

- eGFR  $<30$  mL/min/1.73m<sup>2</sup> **Contraindication/Nephrologist**
- eGFR 30-45 mL/min/1.73m<sup>2</sup> **i.v. Hydration**
- eGFR 45-60 mL/min/1.73m<sup>2</sup> **Oral Hydration**
- eGFR  $>60$  mL/min/1.73m<sup>2</sup> **-**

Metformin

Stop for 2 days when eGFR  $<60$  mL/min/1.73m<sup>2</sup>

# ASSESS PATIENT

- ALLERGY

- ❖ NO ALLERGY OR OTHER ALLERGY (SUBSTANCE, MEDICATION)

- ❖ CONTRAST ALLERGY

Several thin, white, parallel diagonal lines are located in the bottom right corner of the slide, extending from the right edge towards the center.

## Complications

- Acute adverse reactions:

Please see ESUR guidelines for further details on the management and medication dosing for various reactions.

# CONTRAST MEDIA

## Risk factors for acute reactions

### To reduce the risk of an acute reaction

to iodine

For all

For patients

increased

reactive

factors

Oxygen

Adrenaline 1:1,000

Antihistamine H1 - suitable for injection

Atropine

$\beta$ 2-agonist metered dose inhaler

I.V. fluids - normal saline or Ringer's solution

Anti-convulsive drugs (diazepam)

Be prepared

For all

Sphygmomanometer

One-way mouth 'breather' apparatus

contrast medium.

requiring a

persons: use

ably after

drug allergy.

ed because

effectiveness

for resuscitation

- Keep the patient in a medical environment for 30 minutes after contrast agent injection.

# CONTRAST MEDIA

## Contrast Allergy

- ▶ No allergic history
- ▶ Previous mild history to other drug/substance
- ▶ Previous significant allergy to other drug/substance
- ▶ Anaphylaxis to other drug/substance  
OR Mild allergy to Contrast
- ▶ Anaphylaxis to Contrast

nothing

nothing

nothing

Allergologist

No Contrast

- ▶ 12h πριν 32mg κορτιζόνη
  - ▶ 2h πριν 32mg κορτιζόνη
  - ▶ 1h πριν αντιισταμινικό
- 
- Several white lines of varying lengths and orientations are positioned in the bottom right corner of the slide, creating a modern, abstract graphic element.

# PATIENT PREPARATION

## Injection Site

- Preferred site: **right antecubital vein**
- **Large cannula** recommended (e.g. 18 Gauge)
- Impairment of peripheral veins
  - Consider a smaller cannula (e.g. 20G) with subsequent adjustment of contrast media (CM) injection protocol
  - Lower iodine delivery rate (IDR) accordingly

Blood pressure and heart rate should be measured **before** administration of heart rate-slowing medication and/or nitroglycerin

## Iodine delivery rate (IDR)

- The decisive factor in **vascular attenuation**
- IDR (iodine delivery rate (gl/s - gr Iodine/sec):  $CM \text{ concentration (mgI/ml)} \times \text{flow rate (ml/s)} = IDR$  can be modified through these parameters
- IDR adapted to various scan parameters (e.g. body weight, kV)
- higher IDR ( $\geq 2$  gl/s) provides improved image quality

**10 to 10-rule:** A reduction in tube voltage of 10kVp should be followed by a 10 % reduction in IDR and vice versa

## Contrast Medium volume

- Dependent on various scan and patient-related parameters
- Shorter acquisition times may lead to a reduction in total CM volume
- Dependent on both tube voltage and body weight
- The injection duration should be slightly longer than the estimated scan time (optimally 10-20 seconds for most scanners).

## Total Iodine Load

- $CM \text{ concentration (mgI/ml)} \times CM \text{ volume (ml)}$
- Minor relevance as a weight-related aspect in coronary CTA

. CM administration  
(injection route, type, dosage, injection rate)

- ❖ A **non-enhanced, ECG-synchronized cardiac CT** may be performed first to obtain the coronary artery calcium score (CAC) depending on the center (not in patients < 35 years unless specified). Depending on the center, one can consider not to proceed with coronary CTA in patients with high CAC (above 400 or 1000).

**CM viscosity lowered by pre-heating:**

- Accelerated CM distribution
- Lower injection pressure

**CM concentration: 240-400 mgI/ml**

- Different CM concentrations can be used, providing IDR (gI/s) remains constant

**CM Flow Rate**

- Flow rates **up to 6 ml/s** most commonly used in clinical practice
- Flow rates up to 8.8 ml/s considered safe
- Shorter/steeper peak enhancement with a shorter time window

## Saline Chaser

- **Prohibits 20-30 ml of CM retained in the dead space** (injector tubing, peripheral veins)
- Reduces total CM volume and **artifacts of dense contrast material** in the right atrium and ventricle
- Preferably injected **at the same flow rate as CM bolus**

## Timing

### ❑ - Test bolus technique

- Test bolus injection (e.g. 10 ml CM) followed by a saline chaser (identical flow rate)
- repetitive single-slice acquisitions at a pre-specified anatomical level (e.g. ascending aorta) every 1-2 seconds
- An **enhancement curve** is generated to determine the time to peak enhancement, **2-4 seconds should be added for the calculation of the total delay time**

### ❑ - Bolus tracking:

- **Automated scan triggering** by monitoring the arrival of CM bolus by region of interest (ROI) placed at a **pre-defined anatomical level** (the ascending aorta, descending aorta, or a cardiac chamber) with repetitive single-slice scans
- The **scan is triggered when the attenuation reaches a predefined threshold**

## Complications

### ❖ Contrast media extravasation

- The risk increases with a smaller cannula, more peripheral injection sites, and the use of an already existing venous access
- Serious complications: compartment syndrome, ulceration, tissue necrosis but much less common with modern contrast media.
- Treatment may vary according to the protocol in a radiology department.

# ASSESS PATIENT

- BODY HABITUS

BMI

<20 KG/M<sup>2</sup>

>30 KG/M<sup>2</sup>

>40 KG/M<sup>2</sup>

## Body Weight

- Substantial impact on attenuation and time to peak
- Body weight-adapted CM protocol is preferred

# PATIENT PREPARATION

1. Explain procedure
  2. Preparation for Contrast administration
  3. **HEART RATE AND RHYTHM CONTROL**
- 
- Three parallel white diagonal lines are located in the bottom right corner of the slide, extending from the middle of the right edge towards the bottom left.

# HEART RATE CONTROL

## REFERRAL CONSIDERATIONS

- HR>100
  - HIGH RATE ATRIAL FIBRILATION
  - EXTENSIVE EXTRA-SYSTOLIC ACTIVITY
- 
- Three white diagonal lines of varying lengths and positions are located in the bottom right corner of the slide, serving as a decorative element.

Οι επικρατέστερες τεχνικές μείωσης της δόσης ακτινοβολίας είναι οι ακόλουθες:

- ❖ Ελάττωση των kVP
- ❖ Καρδιακός συντονισμός
- ❖ Iterative reconstruction
- ❖ Αξονικοί τομογράφοι νέας γενιάς

## ARTIFACTS AND HOW TO AVOID THEM

- Provide additional saline flush after CM bolus is administered to avoid artifacts from residual CM bolus in the central venous system/right atrium.
- Additional beta-blockers can be administered intravenously to decrease heart rate and avoid unnecessary movement artifacts.
- Lower tube voltages may lead to an increase in blooming artifacts.
- Training of the breath hold command prior to scanning is beneficial to reduce breathing artifacts.

# SCANNING TECHNIQUES

CAREFULL PATIENT SELECTION using GUIDELINES

ALARA: as low as possible  
reasonably achievable



# SCANNING PROTOCOL

## Patient positioning

Optimal centering of the patient in the gantry decreases the radiation dose significantly.

Supine.

Preferably both arms positioned above the head

## TECHNICAL REQUIREMENTS

Data acquisition strategies and scanning protocols may vary depending on scanner manufacturer, system, and institutional preferences.

**Minimum requirement: 64-slice CT systems!!!!!!!**

Dual head injectors with bi- and multiphasic protocols are preferred.

## TECHNICAL REQUIREMENTS

Radiation dose reduction methods to keep radiation dose as low as possible:

- Iterative reconstruction techniques
- Tube voltage:
  - Automated tube voltage selection techniques
  - Low tube voltage scanning
- Tube current: Automated tube current modulation techniques
- ECG-controlled dose modulation
- Preferential use of prospective axial ECG-triggering (or, if available on the scanner, high-pitch acquisition in case of low regular heart rate)

# SCANNING TECHNIQUES

Conversion factor DLP to mSv:  
**0.026** not 0.014

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**HHS Public Access**  
Author manuscript  
*JACC Cardiovasc Imaging*. Author manuscript; available in PMC 2019 January 01.

Published in final edited form as:  
*JACC Cardiovasc Imaging*. 2018 January ; 11(1): 64–74. doi:10.1016/j.jcmg.2017.06.006.

**Cardiac-specific Conversion Factors to Estimate Radiation Effective Dose from Dose-Length Product in Computed Tomography**

Sigal Trattner, PhD<sup>a</sup>, Sandra Halliburton, PhD<sup>b</sup>, Carla M. Thompson, PhD<sup>c</sup>, Yanping Xu, PhD<sup>d</sup>, Anjali Chelliah, MD<sup>e</sup>, Sachin R. Jambawalikar, PhD<sup>f</sup>, Boyu Peng, MS<sup>g</sup>, M. Robert Peters, MD<sup>h</sup>, Jill E. Jacobs, MD<sup>i</sup>, Munir Ghesani, MD<sup>j</sup>, James J. Jang, MD<sup>k</sup>, Hussein Al-Khalidi, PhD<sup>l</sup>, and Andrew J. Einstein, MD, PhD<sup>m,n</sup>

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# SCANNING TECHNIQUES

**Table 1** Description of the main metrics used for characterization of CT radiation dose

|                                       |                                                                                                                                                                                                                                                                                                               |
|---------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Computed tomography dose index (CTDI) | Area under the radiation dose profile for a single rotation and fixed table position along the axial direction of the scanner divided by the total number of detectors for slice thickness and is expressed in coulomb/kg                                                                                     |
| CTDI <sub>100</sub>                   | Integrated radiation dose from acquiring a single scan over a length of 100 m                                                                                                                                                                                                                                 |
| CTDI <sub>w</sub>                     | Average radiation dose to a cross-section of a patient's body determined with the equation $CTDI_w = 2/3 CTDI_{100}$ at periphery + $1/3 CTDI_{100}$ at centre                                                                                                                                                |
| CTDI <sub>vol</sub>                   | Average radiation dose over the volume scanned determined by the equation $CTDI_{vol} = CTDI_w / \text{pitch}$ , where pitch is defined as table movement expressed in millimetres for each 360° gantry rotation, divided by the product of the number of slices and slice width. It is measured in milligray |
| Dose length product (DLP)             | Integrated radiation dose for a complete CT examination measured in milligray×centimetres and calculated by the formula $DLP = CTDI_{vol} \times \text{length irradiated}$                                                                                                                                    |
| Effective dose (ED)                   | Measured as the product between DLP and k, the region-specific conversion factor                                                                                                                                                                                                                              |



European Society  
of Cardiology

European Heart Journal (2018) 39, 286–294  
doi:10.1093/eurheartj/ehx582

**CURRENT OPINION**

*Imaging*

## Strategies for radiation dose reduction in nuclear cardiology and cardiac computed tomography imaging: a report from the European Association of Cardiovascular Imaging (EACVI), the Cardiovascular Committee of European Association of Nuclear Medicine (EANM), and the European Society of Cardiovascular Radiology (ESCR)

Alessia Gimelli<sup>1\*</sup>, Stephan Achenbach<sup>2</sup>, Ronny R. Buechel<sup>3</sup>, Thor Edvardsen<sup>4</sup>, Marco Francone<sup>5</sup>, Oliver Gaemperli<sup>3</sup>, Marcus Hacker<sup>6</sup>, Fabien Hyafil<sup>7</sup>, Philipp A. Kaufmann<sup>3</sup>, Patrizio Lancellotti<sup>8,9</sup>, Koen Nieman<sup>10</sup>, Gianluca Pontone<sup>11,12</sup>, Francesca Pugliese<sup>13</sup>, Hein J. Verberne<sup>14</sup>, Matthias Gutberlet<sup>15</sup>, Jeroen J. Bax<sup>16</sup>, and Danilo Neglia<sup>1</sup>

**Perform scan length optimization**

**Perform a topogram before the contrast-enhanced scan to minimize scan length and overall ED**

Set-up tube voltage and tube current

Consider a trade-off between higher image noise and lower contrast resolution

For clinical practice: tube voltage of 100 and 120 kVp for patients with BMI <30 and >30 kg/m<sup>2</sup>, respectively

Choice of ECG triggering

High heart rate: retrospective ECG triggering with tube current modulation

Low heart rate: prospective ECG-triggering

Last-generation scanner: single-beat acquisition

# SCANNING TECHNIQUES

## VOLTAGE

120kV BMI > 30<sub>KG/M2</sub>, CAC > 100, STENTS

100kV ALL BMI < 30<sub>KG/M2</sub> / > 20<sub>KG/M2</sub>, CAC < 100

140kV BMI > 40<sub>KG/M2</sub>, CAC > 2000

80kV BMI < 20<sub>KG/M2</sub> CAC = 0

**Low tube potentials**—such as 70 or 80 kV—substantially reduce dose compared with the standard use of 100 or 120 kV, whereas high tube currents compensate for **increased image noise**.

Dedicated roentgen tube filters can further reduce dose by effective shielding and modification of the X-ray spectrum. Various types of tube current modulation, to continuously adjust the tube output depending on the type and amount of tissue to be penetrated, can further reduce dose.

**this is not possible for calcium score**

Indeed, the change of scan parameter can influence the CAC value, and therefore, in this setting, only tube current optimization can be performed.

**Perform scan length optimization**

**Perform a topogram before the contrast-enhanced scan to minimize scan length and overall ED**

Set-up tube voltage and tube current

Consider a trade-off between higher image noise and lower contrast resolution

For clinical practice: tube voltage of 100 and 120 kVp for patients with BMI <30 and >30 kg/m<sup>2</sup>, respectively

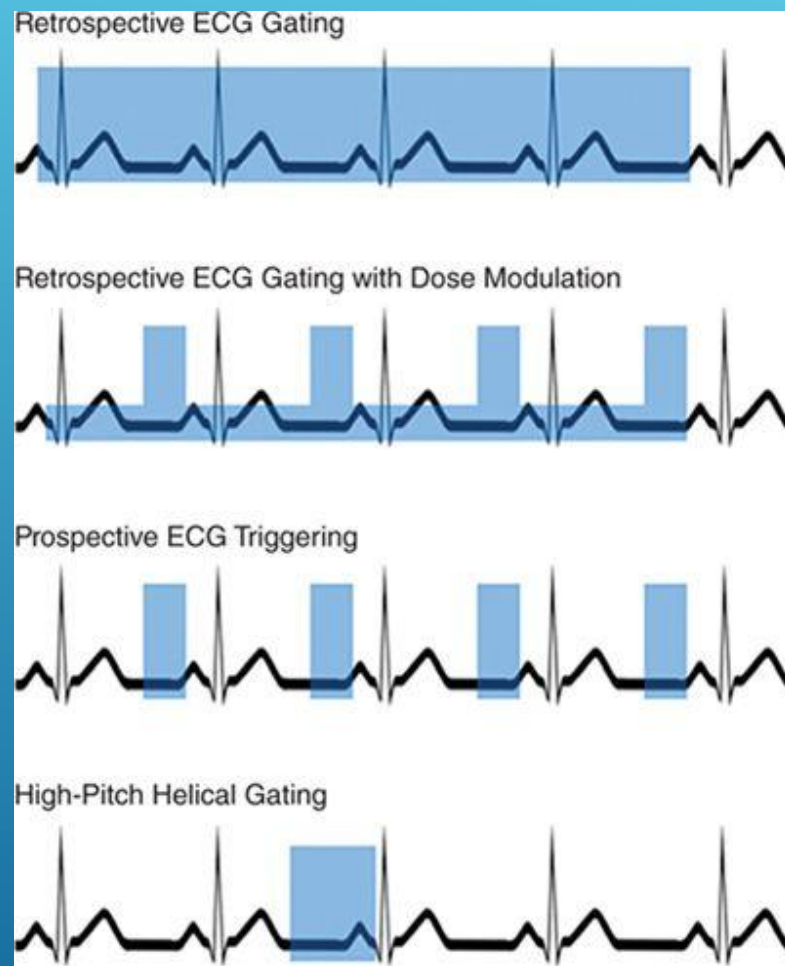
Choice of ECG triggering

High heart rate: retrospective ECG triggering with tube current modulation

Low heart rate: prospective ECG-triggering

Last-generation scanner: single-beat acquisition

# SCANNING TECHNIQUES



# SCANNING TECHNIQUES

Prospective

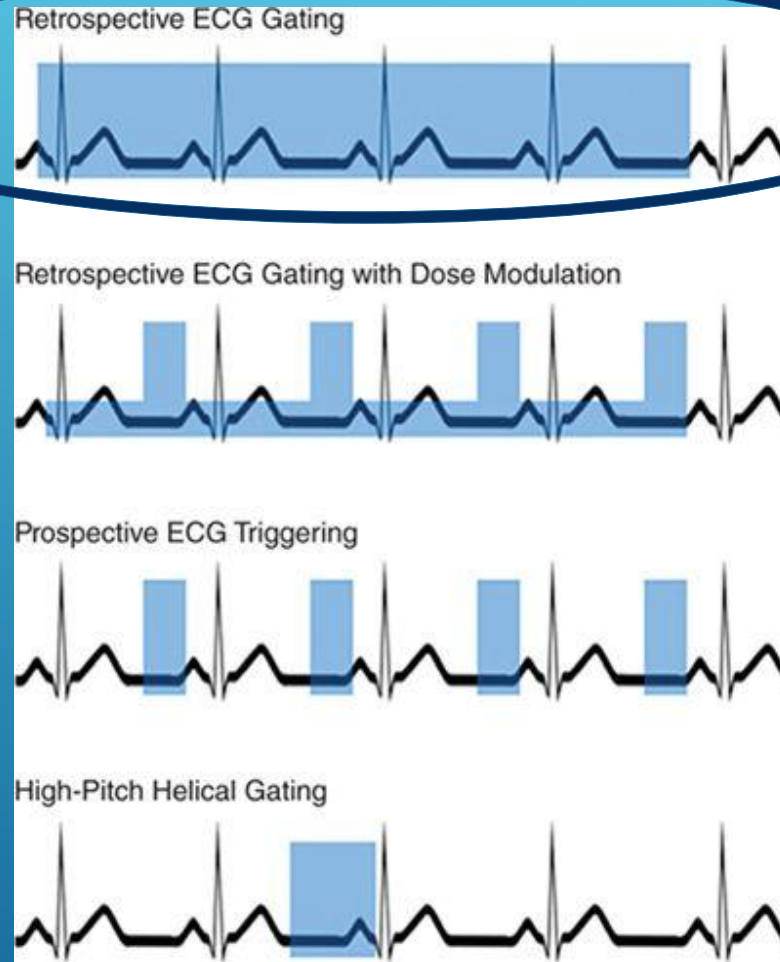
Retrospective **Only in special circumstances**

**Target: 5mSv**

# ECG synchronization/scanning techniques

- Acquisition protocol should be adjusted based on heart rate and rhythm evaluated directly before CTA, after completion of heart rate optimization strategies
- The aim should be to image the coronary arteries in **diastole (60-70% RR-interval)**.
- In case of **high heart rates**, **30 or 40%** RR-phase is preferred.
- In patients with **irregular heart rate**, it may be useful to use **wider RR-interval** (e.g. 30-70%) and/or **absolute time delay reconstructions** (e.g. 700 ms after the R-peak)
- The scanning technique should be optimized depending on the CT system or vendor recommendations.
- **Prospective triggering** is preferred in patients with **slow and stable heart rates** to decrease the radiation dose
- General protocol: Prospective ECG-gating with a sequential (or “step-and-shoot”) data acquisition

# SCANNING TECHNIQUES

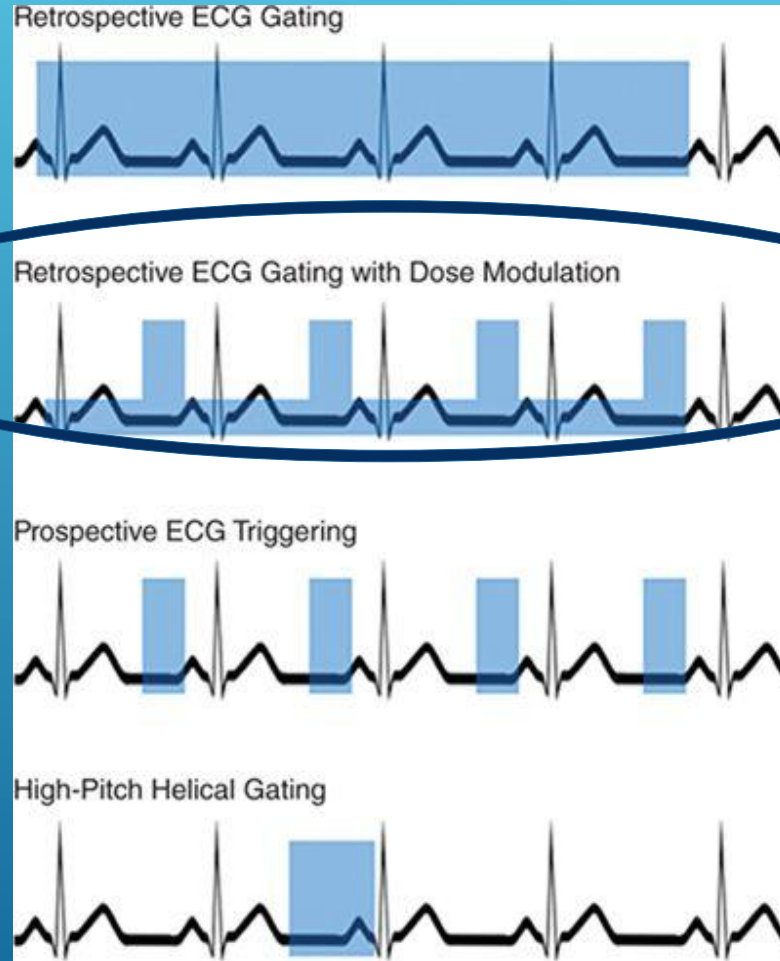


# RETROSPECTIVE ECG-GATING WITH SPIRAL DATA ACQUISITION ONLY IN.....

1. ARRHYTHMIA (ATRIAL FIBRILATION)
2. TACHYCARDIA >75BPM REFRACTORY TO OPTIMAL PHARMACOLOGIC PREPARATION
3. RENAL IMPAIRMENT, OLDER INDIVIDUALS  
( DECREASED INJECTION DURATION → DECREASED CONTRAST VOLUME)
4. DECREASED INSPIRATORY EFFORT
5. CLINICAL SCENARIO/QUESTION
  - AORTIC VALVE MEASUREMENT- PRE-SURGICAL PLANNING
  - SYSTOLIC FUNCTION WHEN OTHER METHODS HAVE RESTRICTIONS (HCM, DEFIBRILATORS)
  - ATRIAL APPENDAGE THROMBUS, ANEURYSM THROMBUS, MASS



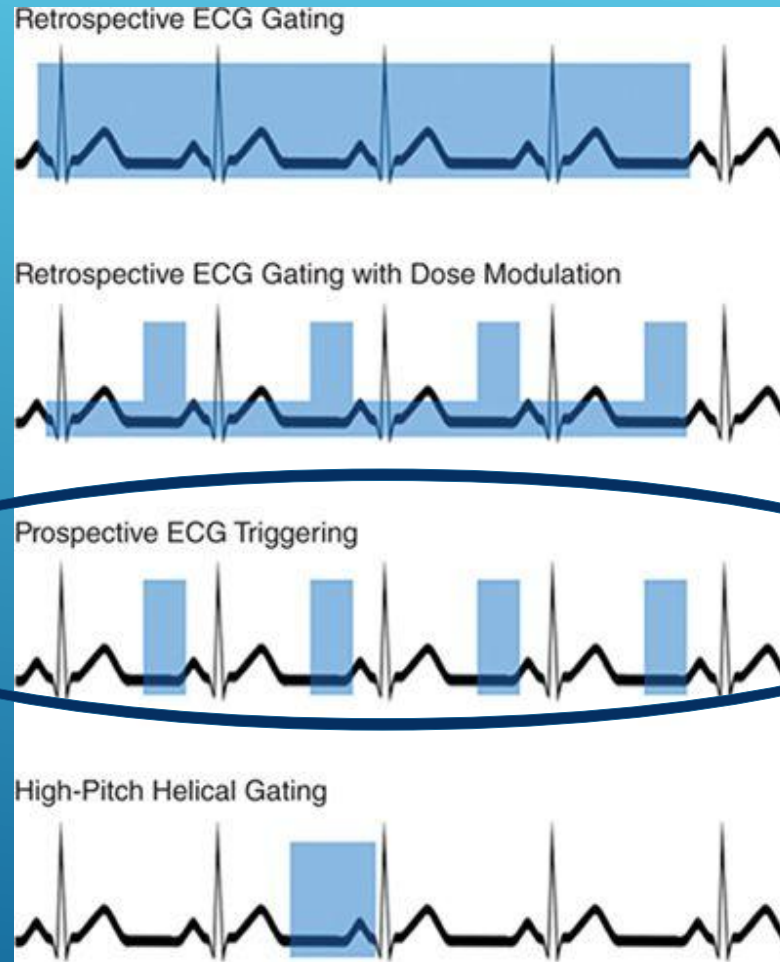
# SCANNING TECHNIQUES



**ECG-triggered X-ray tube current modulation** is an algorithm that can reduce the tube output during the phases that are less likely to be used for the reconstruction.

This approach is effective in terms of radiation dose reduction and should be considered as a standard practice with retrospectively gated spiral CT protocols

# SCANNING TECHNIQUES



**Prospectively** ECG-triggered axial scan protocols, also known as 'sequential' or 'step-and-shoot' protocols,

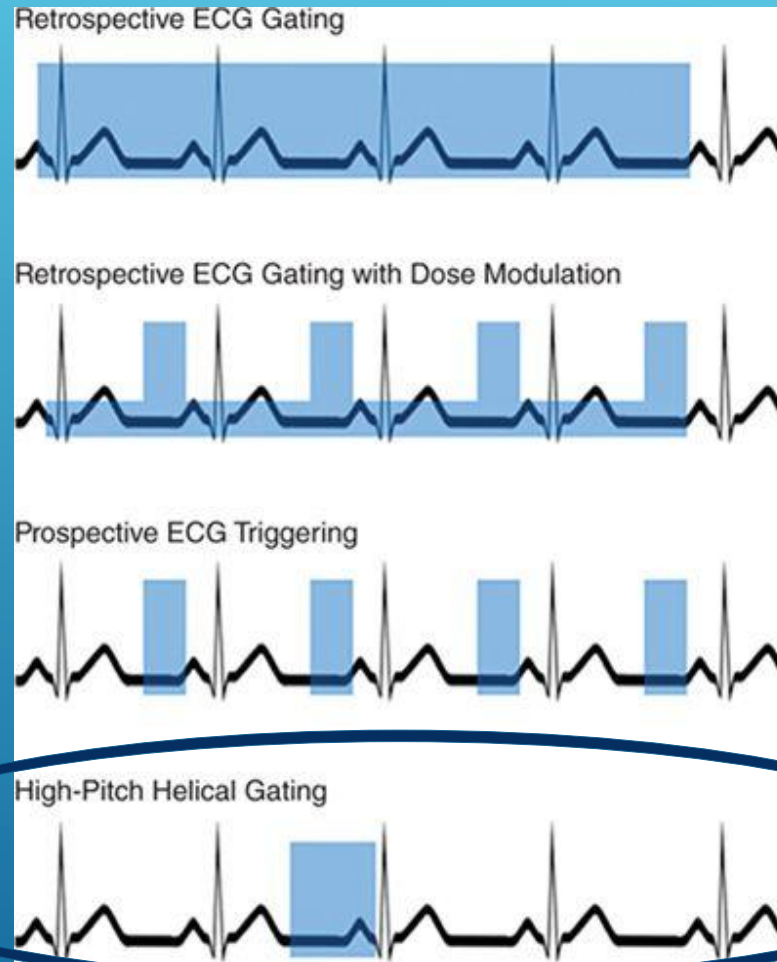
in patients with **stable and low heart rates** (usually below 65 b.p.m.).

The advantage of the axial scan protocol is that **exposure only occurs during the phase that is intended for reconstruction**, minimizing the overall radiation exposure.

The drawback is that it relies on a regular and relatively low heart rate. Depending on the system, no alternative cardiac phases may be available in the case of suboptimal image quality.

More recent systems operate axial scan protocols that allow for prolonged sampling and reconstruction of additional phases (also known as 'padding') and are also equipped with arrhythmia detection and handling algorithms. In the event of an irregular heartbeat, the acquisition at a given location is interrupted and/or repeated.

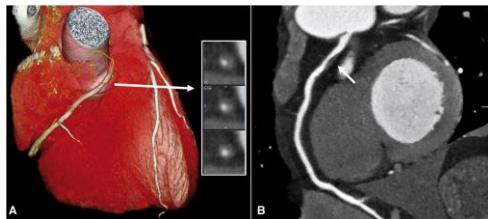
# SCANNING TECHNIQUES



# Iterative reconstruction

Αποτελεί μια μέθοδο ανασύνθεσης 2D και 3D εικόνων, αναγνωρίζοντας συγκεκριμένες προβολές ενός αντικειμένου και χρησιμοποιώντας παράλληλα στατιστικά μοντέλα επαναληψιμότητας για να ελαττώσει τον θόρυβο της εικόνας.

Η συγκεκριμένη τεχνική εκτός από την μείωση της δόσης ακτινοβολίας, επιτυγχάνει την βελτιστοποίηση της αντίθεσης και της χωρικής ανάλυσης.



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spectral CT



Dual-energy CT, is a computed tomography technique that uses two separate x-ray photon energy spectra,  
allowing the interrogation of materials that have different attenuation properties at different energies.

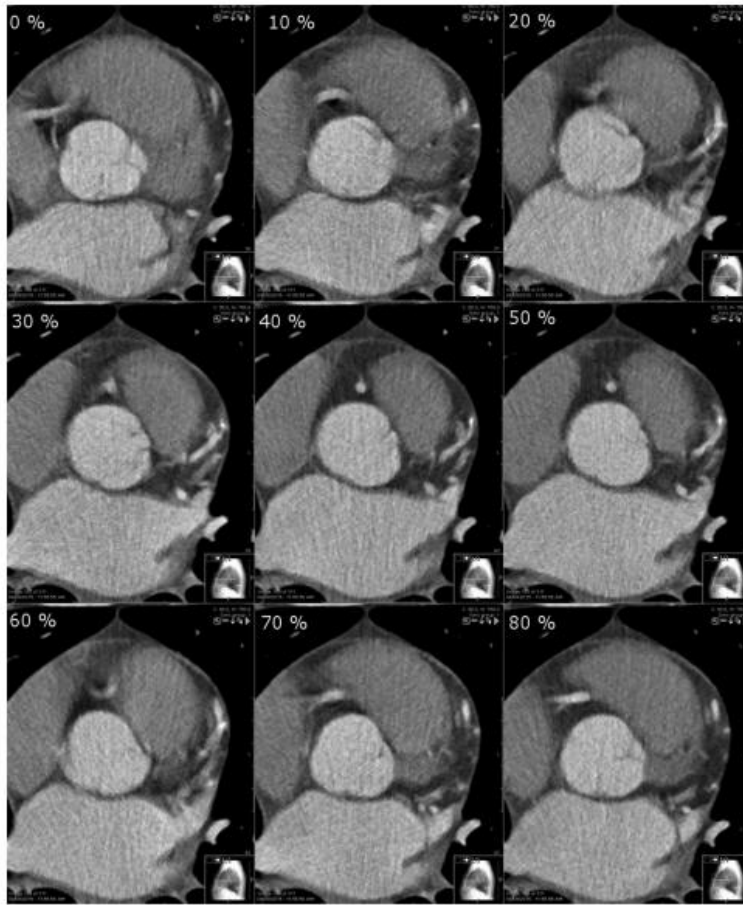
All these lower dose  
acquisition protocols  
require  
lowering of the heart rate.

Several thin, parallel white lines are drawn diagonally across the bottom right corner of the slide, extending from the right edge towards the bottom left.

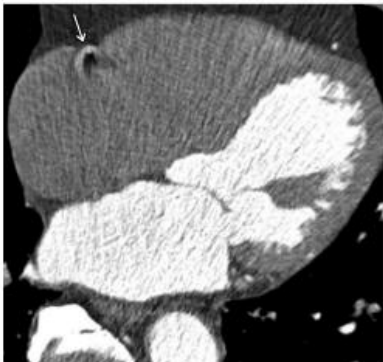
# Artefacts

## Selection of reconstruction window.

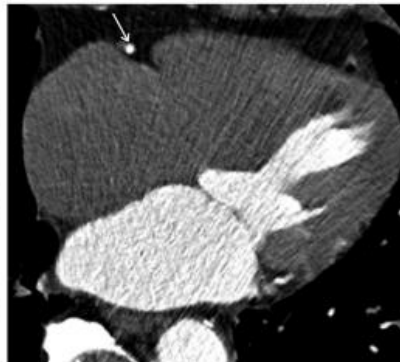
- (a) different phases of the cardiac cycle (from 0% to 80% R-R interval) show that the right coronary artery has varying degrees of motion in each of the cardiac phases. In this patient, the motion is least in the 50% and 80% phases of the R-R interval.
- (b) reconstructed from the 75% R-R interval in a patient with atypical chest pain shows winging of the right coronary artery (arrow).
- (c) reconstruction at the 40% R-R interval (same patient as in b) shows that the artifact has disappeared, with good-quality visualization of the right coronary artery (arrow).



a.



b.



c.

**Table 3: Postprocessing Techniques for Reducing Artifacts from Arrhythmias**

| Problem                                            | Solution                                                                                                                             |
|----------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| Sinus tachycardia                                  | Multisegment reconstruction                                                                                                          |
| Gating issue: triggering from T wave/atrial pacing | New synchronization markers (syncs) in appropriate position                                                                          |
| PVC with post-PVC pause                            | Eliminate sync from PVC, two separate syncs in diastolic pause                                                                       |
| PVC without pause                                  | Eliminate sync from PVC                                                                                                              |
| Premature atrial contraction                       | Eliminate premature atrial contraction sync or retain premature atrial contraction sync with reconstruction from best systolic phase |
| First-degree atrioventricular block                | Sync just before R wave or in systolic phase                                                                                         |
| Atrial tachycardia                                 | Sync in best systolic phase                                                                                                          |
| Ventricular tachycardia                            | Cannot be fixed                                                                                                                      |
| Atrial fibrillation                                | End diastolic sync in slow heart rates<br>Systolic sync in high heart rates<br>Transient episode: elimination of sync                |
| Marked bradycardia                                 | Two separate syncs in diastole                                                                                                       |

# Artefacts

Respiratory motion artifact



Imaging Physics

## Artifacts at Cardiac CT: Physics and Solutions

Kevin Kalisz, Ji Buethe<sup>1</sup>, Sachin S. Saboo, Suhny Abbata, Sandra Halliburton, Prabhakar Rajiah

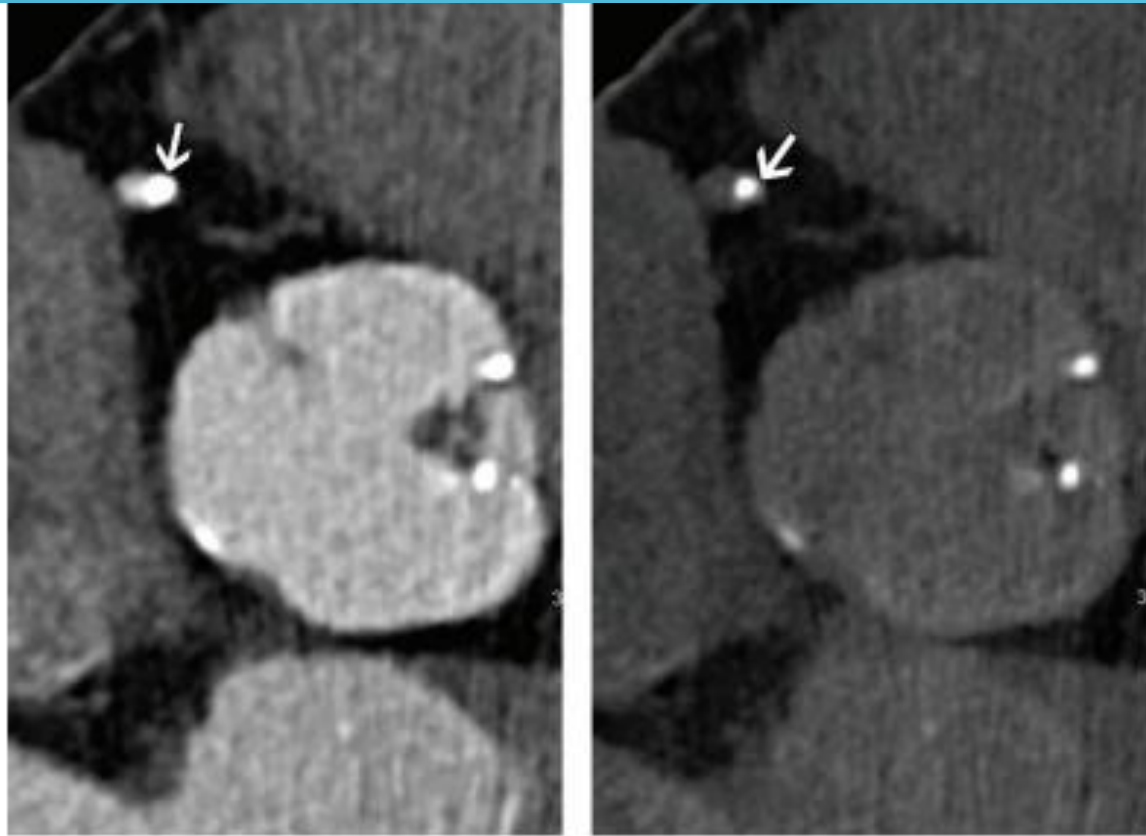
✓ Author Affiliations

Published Online: Oct 21 2016 | <https://doi.org/10.1148/rg.2016160079>



# Artefacts

## Calcium blooming



Imaging Physics

## Artifacts at Cardiac CT: Physics and Solutions

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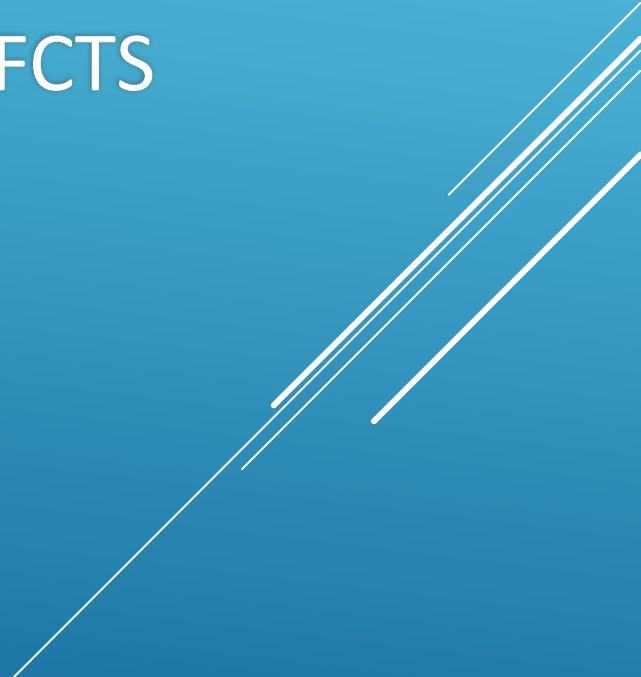
RadioGraphics



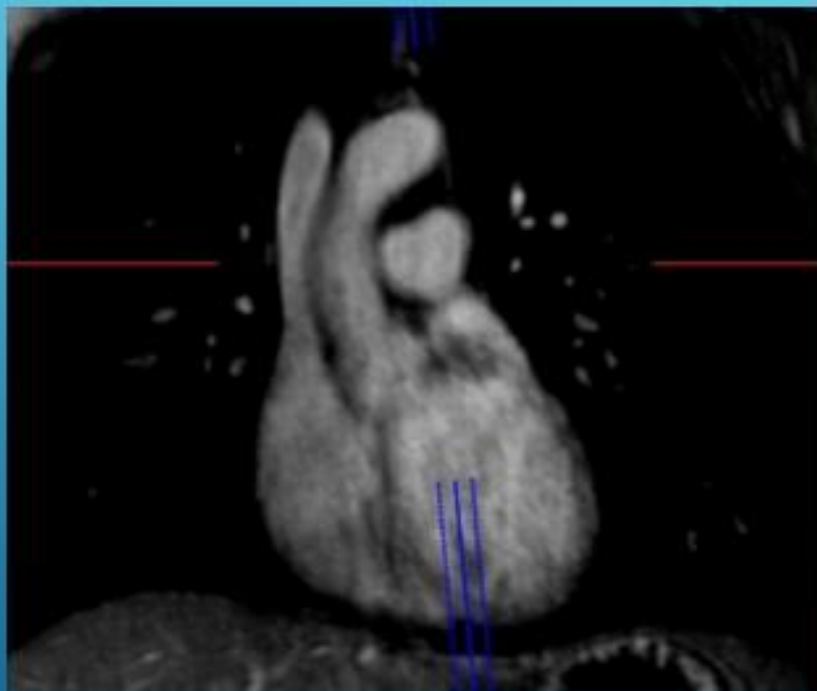
## TAKING HOME MESSAGE

- ❖ Ακολουθείτε τα Guidelines
- ❖ Σωστή επιλογή των ασθενών

# TAKE HOME MESSAGES

- THOROUGH HISTORY TAKING TO OPTIMISE PROTOCOL  
rate, rhythm, breath-hold, Hot Flash, Hydration
  - OPTIMAL PATIENT PREPARATION CALCIUM SCORE  
optimize scan based on CAC, z axis coverage
  - OPTIMAL PROTOCOL SELECTION, PREDICT ARTIFACTS
  - MULTIPLE RECONS/POST PROCESSING
  - RADIATION REDUCTION ATTITUDE
- 
- A series of three parallel white diagonal lines extending from the bottom right towards the top right of the slide.





Σας  
ευχαριστώ!



Μονάδα Ερευνάς Ακτινολογίας και Ιατρικής Απεικόνισης  
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