

# Beeldvorming bij coronairlijden

## Wat, bij wie en wanneer?

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Luchtvaart Cardiologie Symposium 25.04.25  
Centrum voor Mens en Luchtvaart, Soesterberg





|                                                                                                                               |                   |
|-------------------------------------------------------------------------------------------------------------------------------|-------------------|
| Potentiële belangenverstrengeling                                                                                             | Geen              |
| Voor bijeenkomst mogelijk relevante relaties met bedrijven                                                                    | Geen              |
| Sponsoring of onderzoeksgeld<br>Honorarium of andere (financiële) vergoeding<br>Aandeelhouder<br>Andere relatie, namelijk ... | Geen vermeldingen |



# Wat gaan we bespreken

- Achtergrond van coronairlijden
- Diagnostische strategie adhv ESC-richtlijn
- Verschillende diagnostische modaliteiten
- Korte interactieve casuïstiek
- Betekenis in luchtvaart
- Discussie – maar onderbreek mij vooral bij vragen!







CARDIOEXPERT

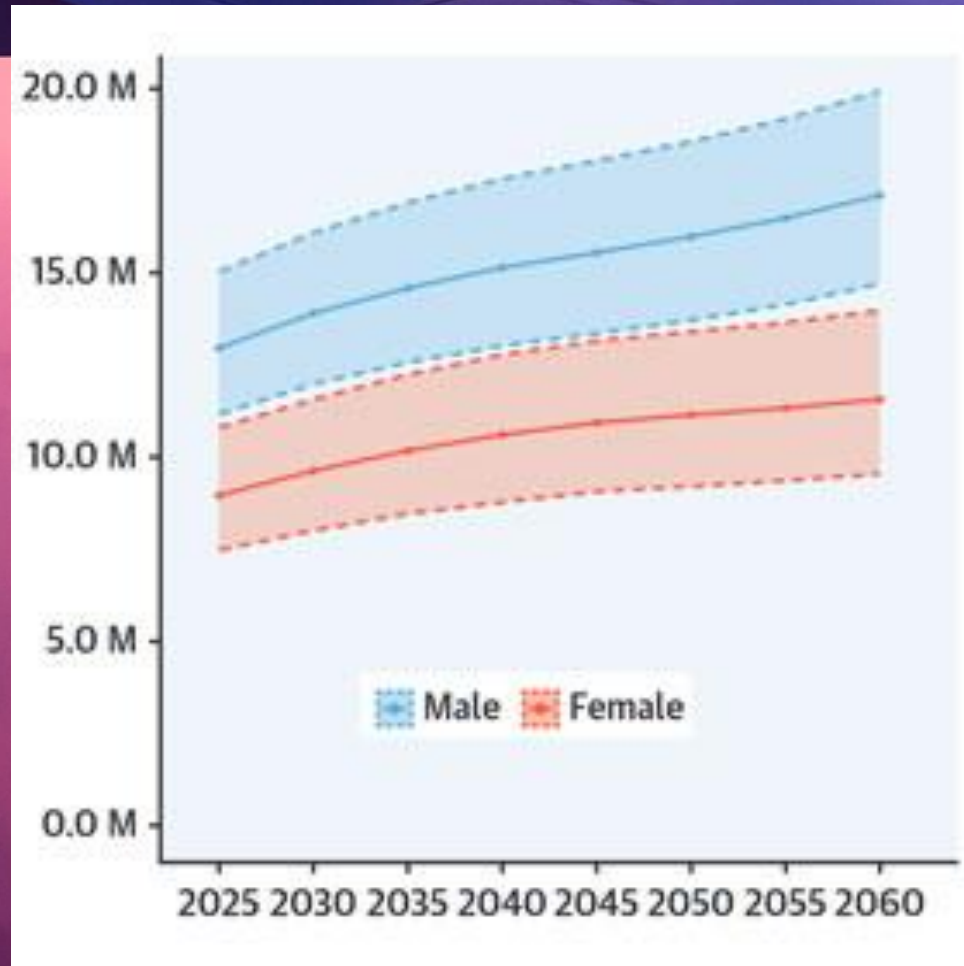
# De epidemie van coronairlijden

- Prevalentie coronairlijden in Europa: 47.6 miljoen patiënten
- Acuut myocardinfarct:
  - incidentie neemt af
  - Mortaliteit 60% gedaald sinds 1990

Maar... Prevalentie van risicofactoren neemt toe!



# Projected incidence of acute myocardial infarction in the US

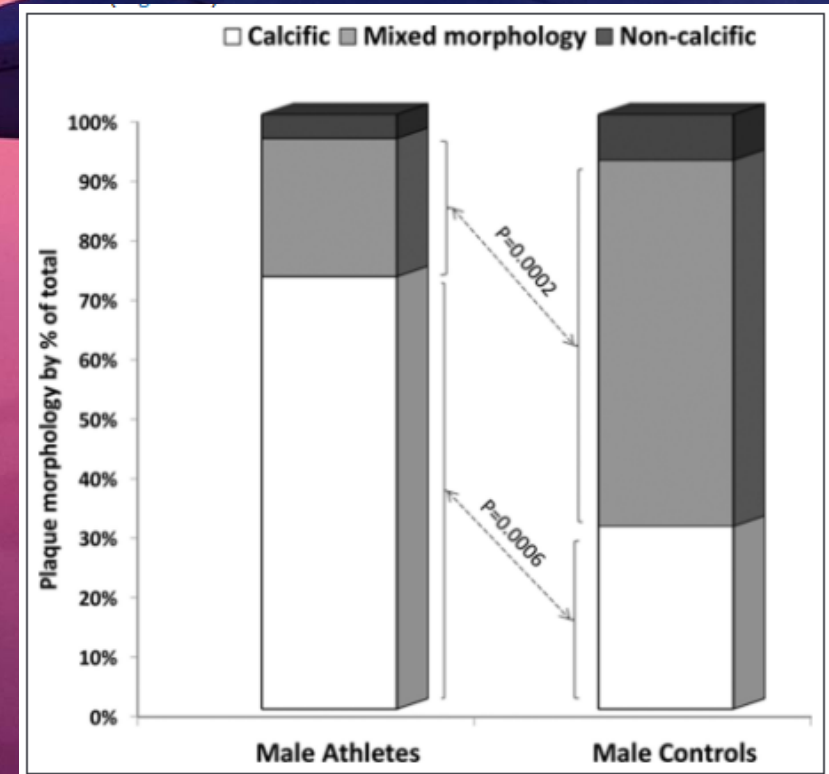
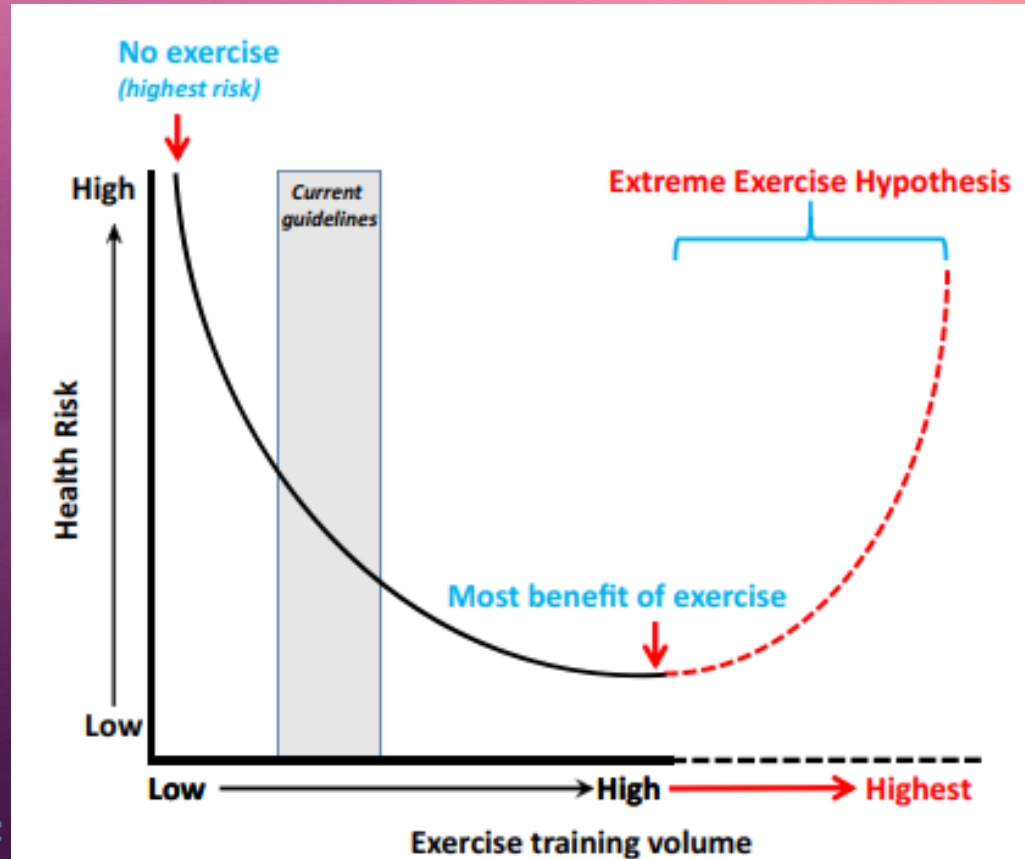


Mohebi e.a., JACC 2022





# Extreme exercise hypothesis



# Diagnostische uitdaging



ESC

European Society  
of Cardiology

European Heart Journal (2024) 45, 3415–3537  
<https://doi.org/10.1093/eurheartj/ehae177>

ESC GUIDELINES

## 2024 ESC Guidelines for the management of chronic coronary syndromes

Developed by the task force for the management of chronic coronary syndromes of the European Society of Cardiology (ESC)

*Endorsed by the European Association for Cardio-Thoracic Surgery (EACTS)*

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CARDIOEXPERT

# Bij wie?

- Patient met 'typische' stabiele angina pectoris
- Stabiele patient post-myocardinfarct
- Stabiele patient met gekend (ischemisch) hartfalen
- Patient met angina zonder obstructief epicardiaal coronairlijden
- **Patient bij wie coronairlijden zich openbaart n.a.v. screening of als toevalsbevinding**



# 4-step approach

## Step 1 Initial evaluation



Non-cardiac reason for symptoms identified: treat underlying cause

History, symptoms, physical examination  
Resting ECG. Biochemistry  
Pulmonary function test<sup>a</sup>  
Chest X-ray<sup>a</sup>

Unstable cardiac symptoms with angina, heart failure or arrhythmia: acute assessment by the ED

## Step 2 Further evaluation



Very low clinical likelihood of obstructive CAD ( $\leq 5\%$ ): consider deferring further testing<sup>b</sup>

Assess clinical likelihood of obstructive CAD  
Echocardiography at rest  
Exercise ECG<sup>a</sup>

Severe comorbidities or low quality of life: consider no further testing and treat medically

## Step 3 Confirming diagnosis and estimating event-risk



Consider ANOCA/INOCA



Further non-invasive testing recommended based on clinical likelihood, availability, local expertise, patient characteristics and preference<sup>b</sup>

Invasive angiography if:  
• Very high clinical likelihood ( $>85\%$ )  
• Suspicion of high-risk obstructive CAD  
• Severe myocardial ischaemia

CCTA: obstructive CAD?

- In individuals with low and moderate ( $>5-50\%$ ) clinical likelihood

Selective second-line imaging to increase post-test likelihood

Functional imaging: myocardial ischaemia?

- In individuals with moderate and high ( $>15-85\%$ ) clinical likelihood

## Step 4 Treatment



Lifestyle and risk factor modification  
• To improve prognosis



Disease-modifying medical treatment  
• To improve prognosis

Revascularization if:  
• high risk of adverse events  
• GDMT fails to relieve symptoms



Revascularization  
• To reduce symptoms  
• To improve prognosis in patients with obstructive CAD who are at high risk of adverse events



Antianginal medical treatment  
• To reduce symptoms



# Stap 1

## Anamnese lichamelijk onderzoek ECG Lab



### Symptom characteristics

Decreasing likelihood of CCS



Increasing likelihood of CCS



#### Chest discomfort

##### Quality

- Burning
- Sharp
- Tearing - Ripping
- Pleuritic
- Aching

- Strangling
- Constricting
- Squeezing
- Pressure
- Heaviness

##### Location and size

- Right
- Shifting
- Large area or fine spot

- Retrosternal
- Extending to left arm, or to jugular or intrascapular region
- "Fist"-size

##### Duration

- Lasting

- Short: up to 5–10 min if triggered by physical exertion or emotion

##### Trigger

- At rest
- On deep inspiration or when coughing
- When pressing on ribs or sternum

- On effort
- More frequent in cold weather, strong winds or after a heavy meal
- Emotional distress (anxiety, anger, excitement or nightmare)

##### Relief

- By antacids, drinking milk

- Subsiding within 1–5 min after effort discontinuation
- Relief accelerated by sublingual nitroglycerin



#### Dyspnoea

##### Quality

- Difficulty to exhale
- With wheezing

- Difficulty catching breath

##### Trigger

- Both at rest and on effort
- While coughing

- On effort

##### Relief

- Slowly subsiding at rest or after inhalation of bronchodilators

- Rapidly subsiding after effort discontinuation



# Stap 2 – further evaluation

- Risk-factor weighted clinical likelihood
- Pre-test likelihood <5% (“very low”)- i.p. geen verdere evaluatie nodig
- Indien low, moderate of high (15-50%; 50-85%; >85%) → verdere diagnostiek

Hierin geen overwegingen t.a.v. beroep meegenomen!



1

## Symptom score (0–3 points)

## Chest pain characteristics

|                   |                                                                                           |
|-------------------|-------------------------------------------------------------------------------------------|
| Type and location | Constricting discomfort located retrosternally or in neck, jaw, shoulder or arm (1 point) |
| Aggravated by     | Physical or emotional stress (1 point)                                                    |
| Relieved by       | Rest or nitrates within 5 min (1 point)                                                   |

## Dyspnoea characteristics

Shortness of breath and/or trouble catching breath aggravated by physical exertion (2 points)

## Symptom score

Main symptom either:

Chest pain  
(0–3 points)

or

Dyspnoea  
(2 points)

2

## Number of risk factors for CAD (0–5):

Family history, smoking, dyslipidaemia, hypertension and diabetes

3

## Estimate the Risk Factor-weighted Clinical Likelihood (RF-CL) of obstructive CAD

| Number of risk factors | Symptom score |     |     |     |     |     |          |     |     |     |     |     |          |     |     |     |     |     |
|------------------------|---------------|-----|-----|-----|-----|-----|----------|-----|-----|-----|-----|-----|----------|-----|-----|-----|-----|-----|
|                        | 0–1 point     |     |     |     |     |     | 2 points |     |     |     |     |     | 3 points |     |     |     |     |     |
|                        | Women         |     |     | Men |     |     | Women    |     |     | Men |     |     | Women    |     |     | Men |     |     |
|                        | 0–1           | 2–3 | 4–5 | 0–1 | 2–3 | 4–5 | 0–1      | 2–3 | 4–5 | 0–1 | 2–3 | 4–5 | 0–1      | 2–3 | 4–5 | 0–1 | 2–3 | 4–5 |
| Age 30–39              | 0             | 1   | 2   | 1   | 2   | 5   | 0        | 1   | 3   | 2   | 4   | 8   | 2        | 5   | 10  | 9   | 14  | 22  |
| Age 40–49              | 1             | 1   | 3   | 2   | 4   | 8   | 1        | 2   | 5   | 3   | 6   | 12  | 4        | 7   | 12  | 14  | 20  | 27  |
| Age 50–59              | 1             | 2   | 5   | 4   | 7   | 12  | 2        | 3   | 7   | 6   | 11  | 17  | 6        | 10  | 15  | 21  | 27  | 33  |
| Age 60–69              | 2             | 4   | 7   | 8   | 12  | 17  | 3        | 6   | 11  | 12  | 17  | 25  | 10       | 14  | 19  | 32  | 35  | 39  |
| Age 70–80              | 4             | 7   | 11  | 15  | 19  | 24  | 6        | 10  | 16  | 22  | 27  | 34  | 16       | 19  | 23  | 44  | 44  | 45  |

Clinical likelihood: ● Very low ● Low ● Moderate



# Pre-test probability (2019) overschat

**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>64</sup> of contemporary data<sup>7,8,62</sup>

|       | Typical |       | Atypical |       | Non-anginal |       | Dyspnoea <sup>a</sup> |       |
|-------|---------|-------|----------|-------|-------------|-------|-----------------------|-------|
| Age   | 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%   |

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# Stap 2 – Verdere evaluatie

Aanvullende diagnostiek kan worden ingezet om risicocategorie te veranderen

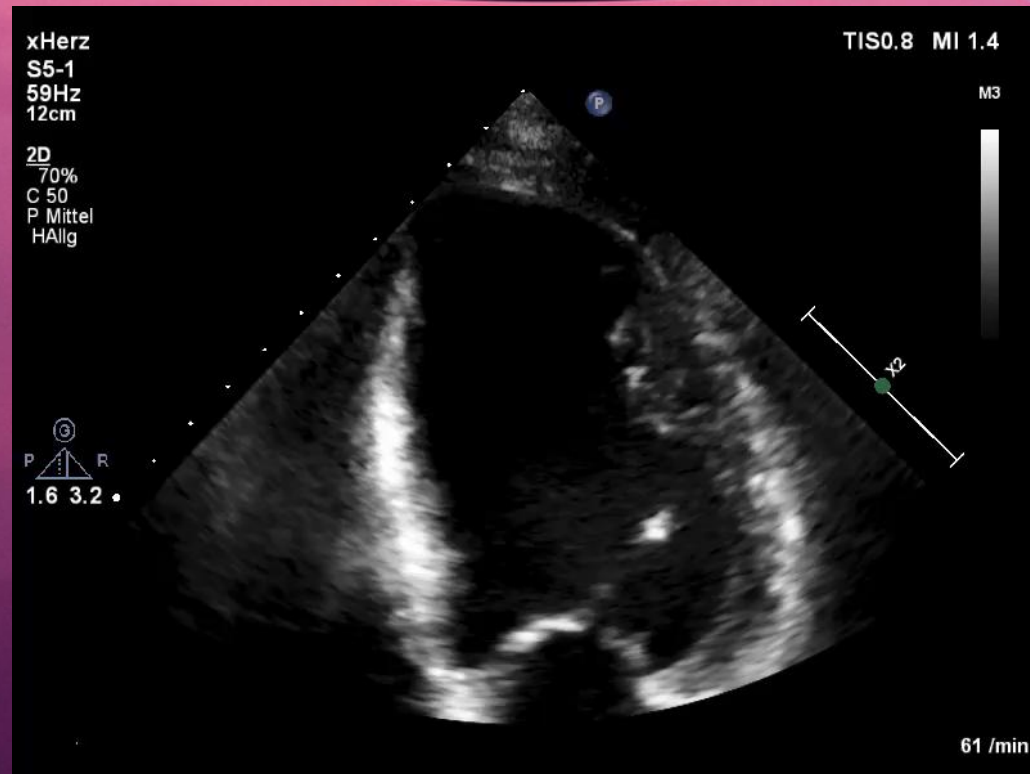
Bijv: Low risk + normale fietstest = very low risk

Alternatieve verklaring



# Stap 2 - TTE

## Regionale wandbewegingsstoornissen

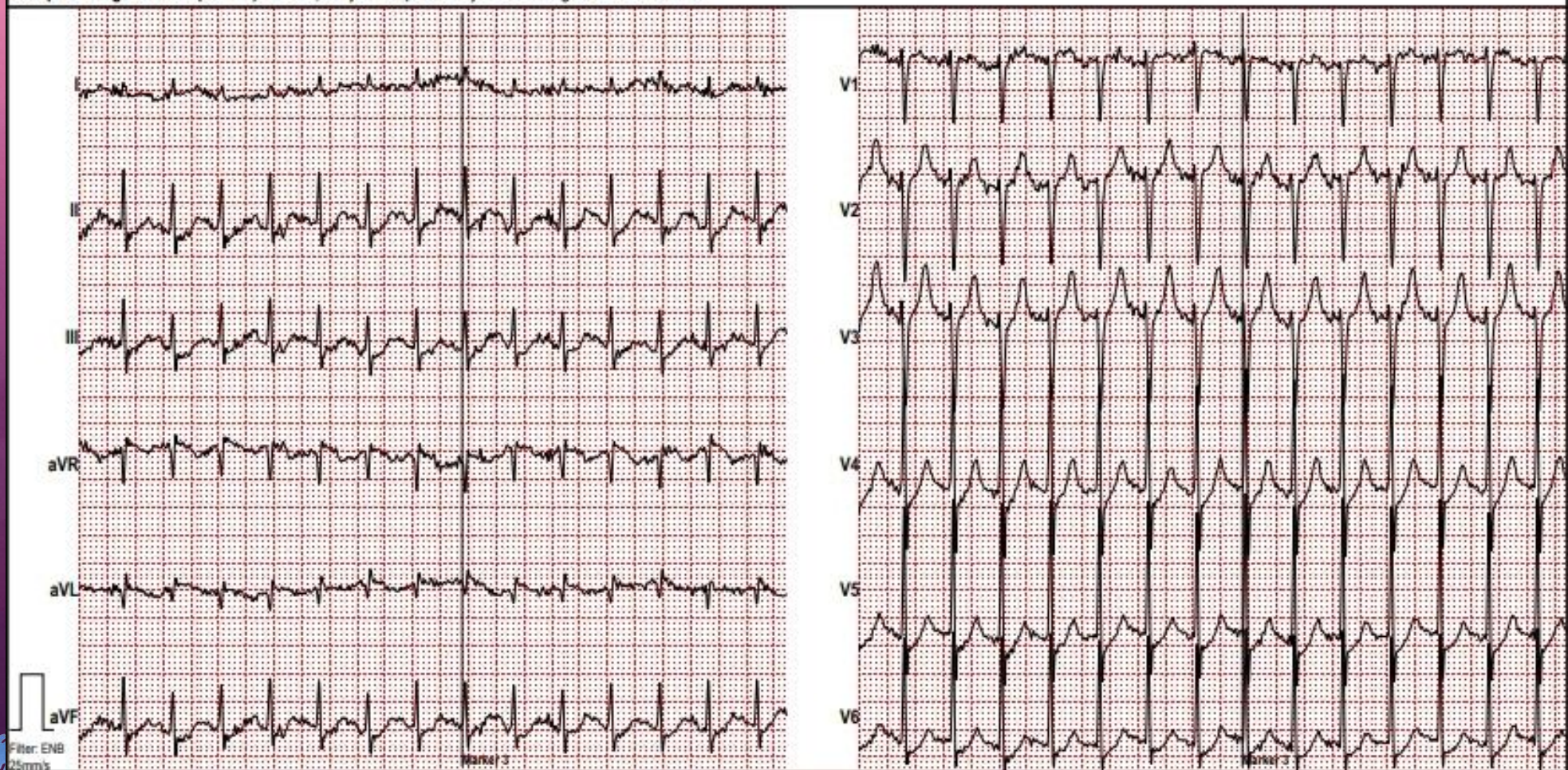


## Stap 2 – X-ECG

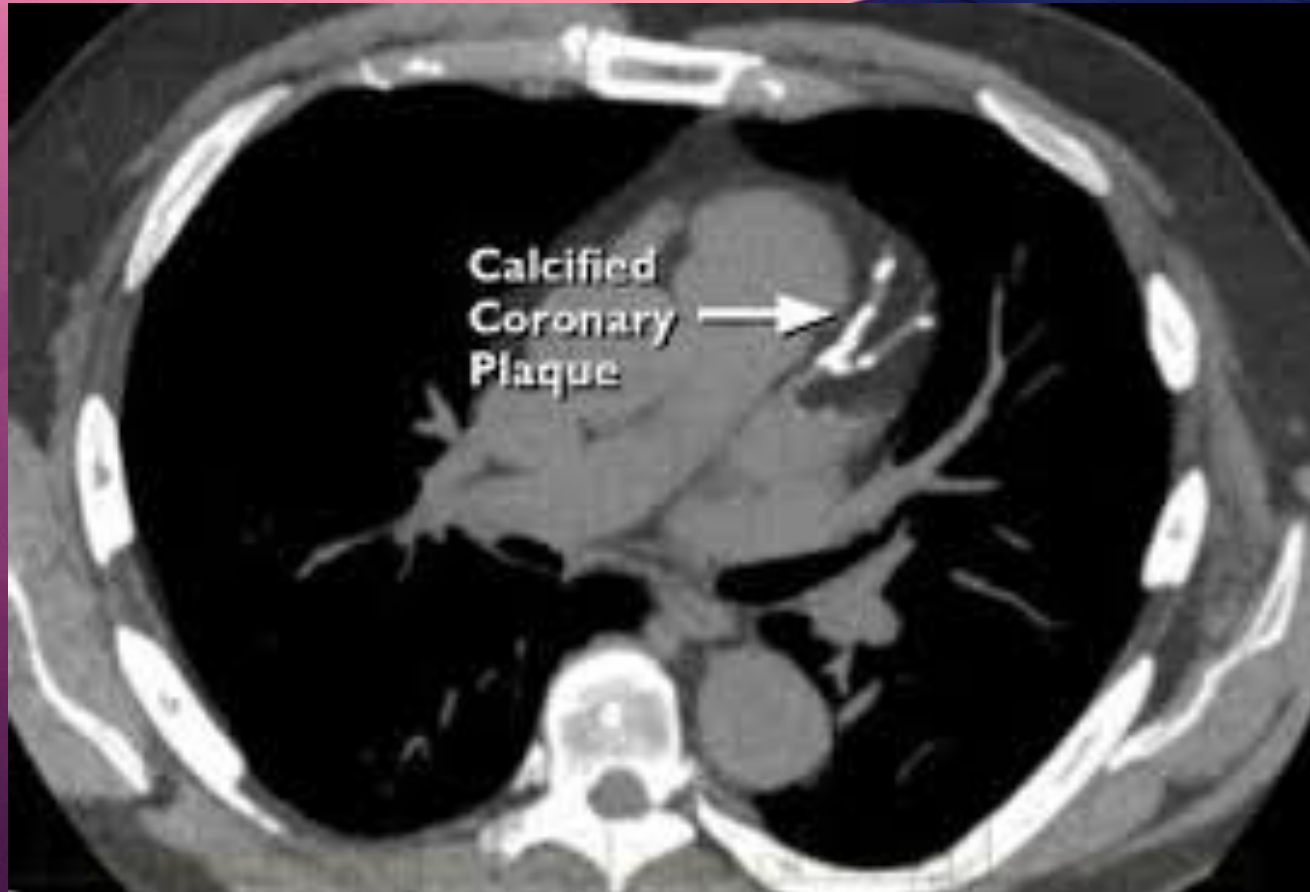
- Makkelijk, goedkoop
- Specificiteit en met name sensitiviteit inferieur t.o.v. hedendaagse beeldvorming
- Nieuwe rol: geen diagnosticum, maar ter risicostratificatie



Ramp 20 Stage 8 136W(90/min)MET's:7,6 Tijd in stap:0:50 Tijd in belasting:9:50 HF:170/min



# Stap 2 – CT-calciumscore



# Stap 3 – confirming diagnosis

## Anatomische test

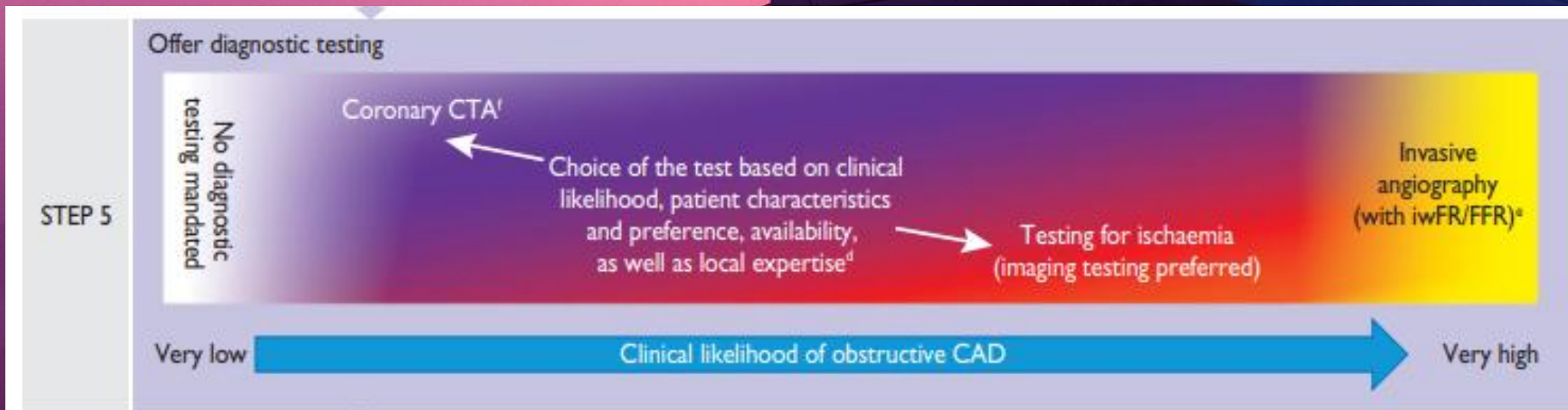
CT-coronairen; CAG

## Functionele test

(X-ECG); Stressechocardiografie; MRI-perfusie;  
SPECT; PET-CT



# Richtlijn 2019



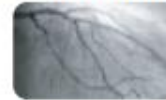
Clinical likelihood of obstructive CAD<sup>a</sup>

Very high  
>85%



Appropriate first-line test for suspected CCS

Invasive coronary angiography



High  
>50–85%



Functional imaging



PET/SPECT



CMR



Stress ECHO

Moderate  
>15–50%



CCTA



OR

Functional imaging



PET/SPECT



CMR



Stress ECHO

Low  
>5–15%



Adjust the clinical likelihood



OR

CCTA



Very low  
≤5%



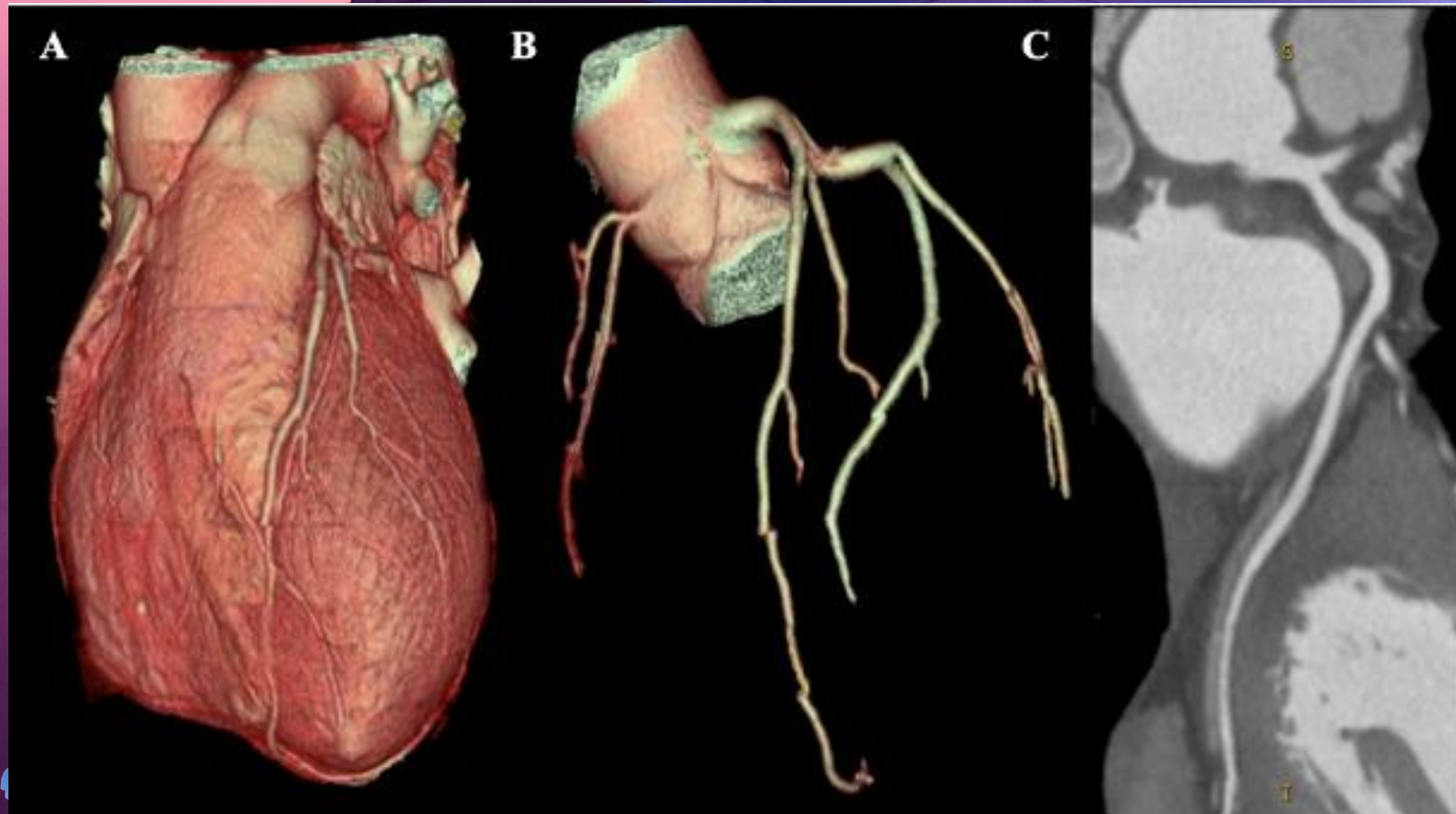
Defer further testing

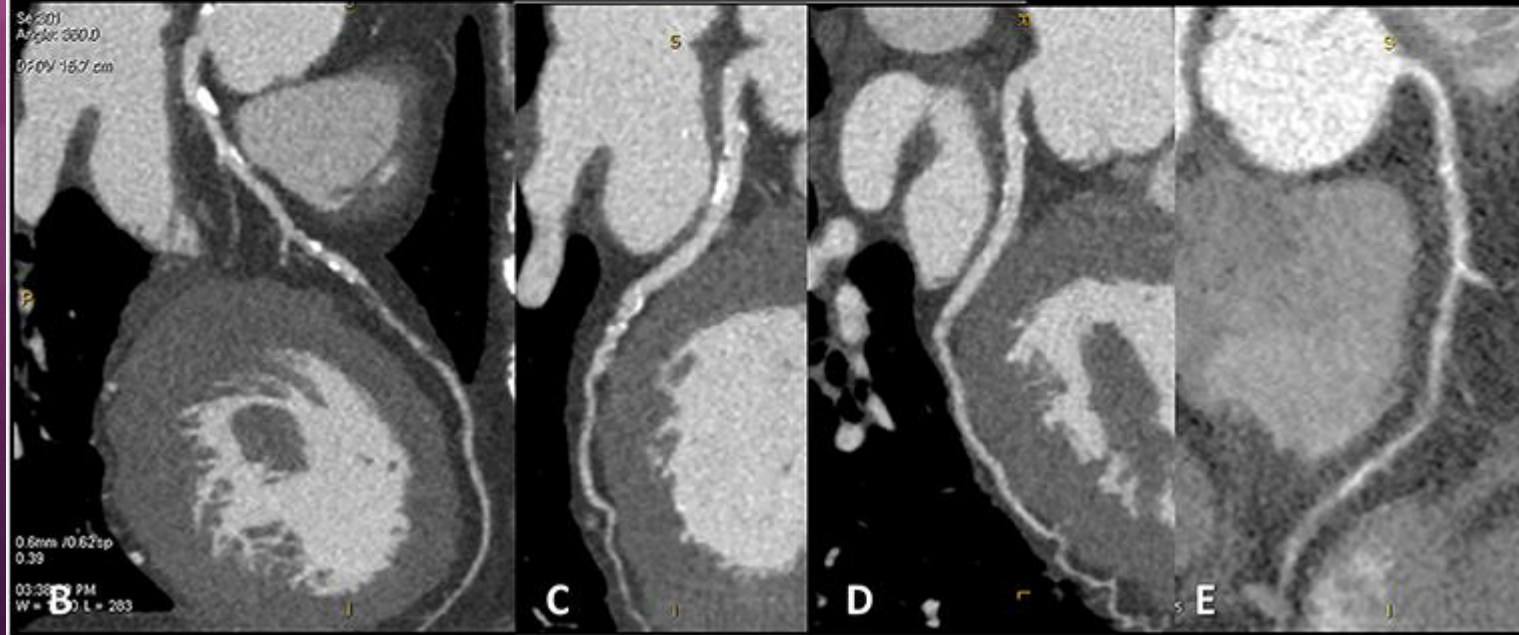
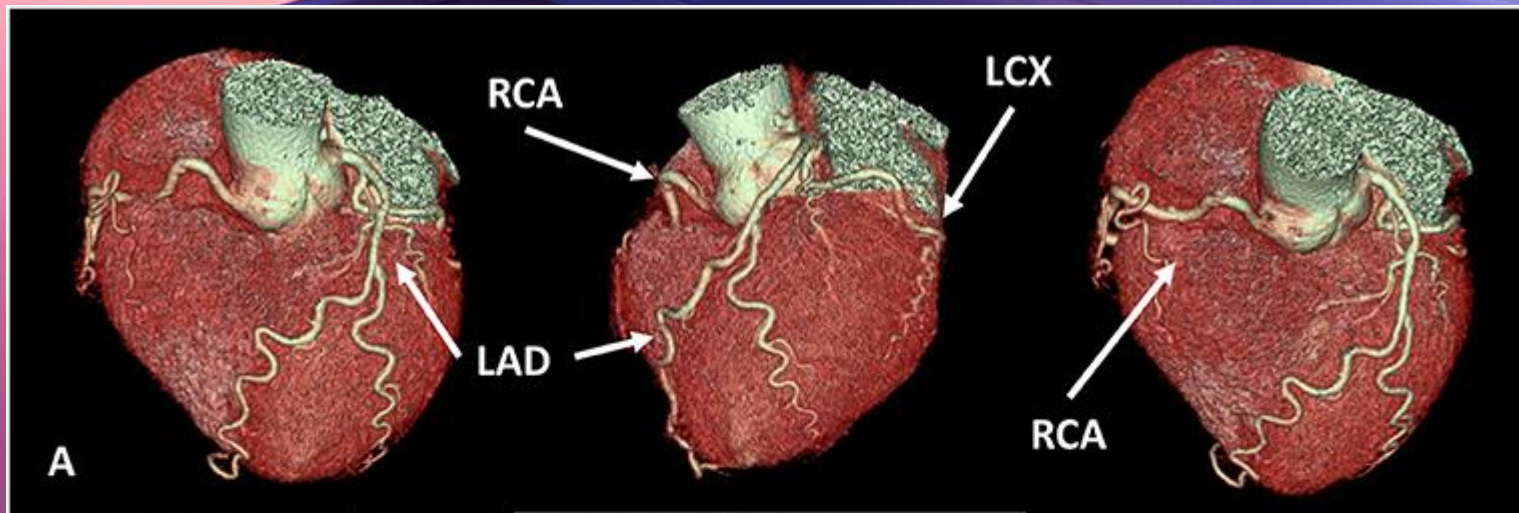


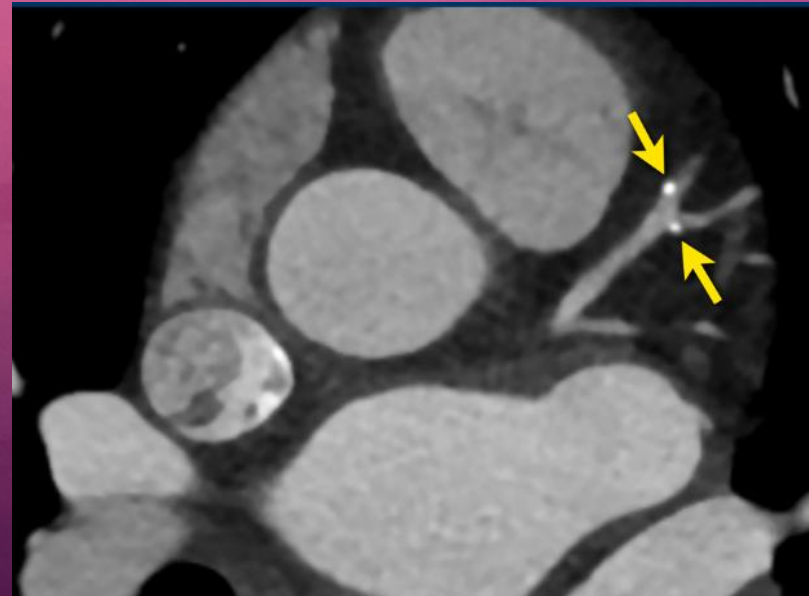
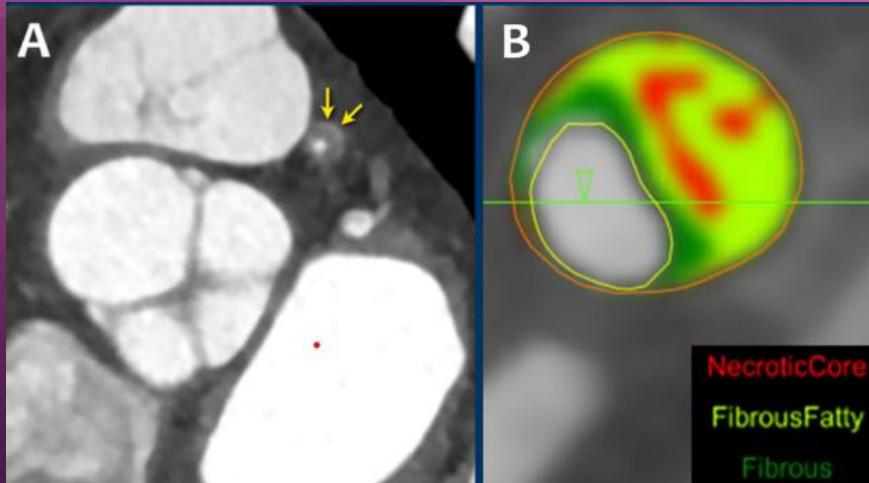
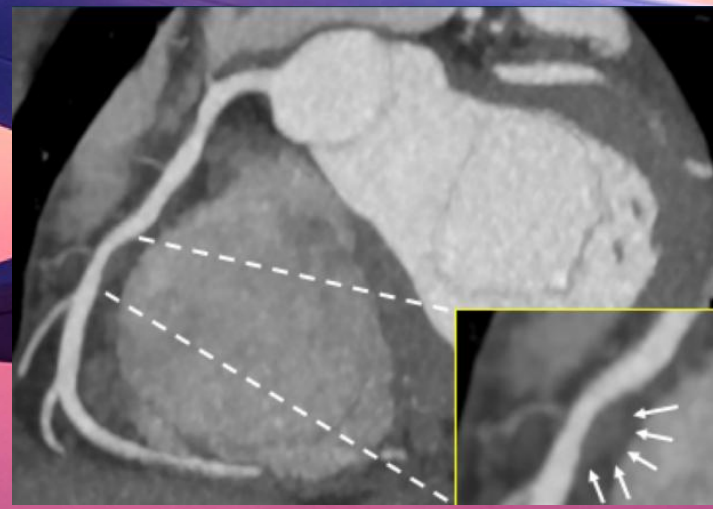
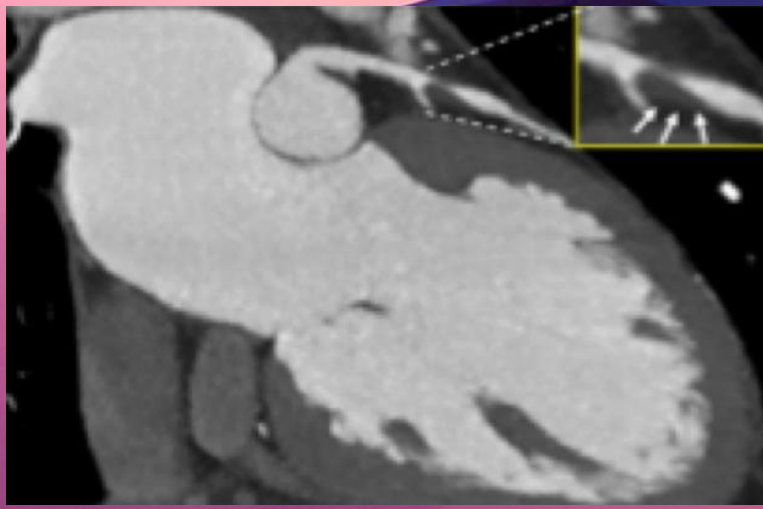
# CT-coronairen

- Klasse I indicatie bij RF-CL 5-50%
- Visualisatie coronairen met contrast
- Classificatie van stenoses
  - <50%: Niet obstructief
  - 50-70%: Intermediair
  - >70%: Obstructief
- Plaque features
- Gestandaardiseerde rapportage: CAD-RADS
- SCOT-HEART studie: Mortaliteit/MACE 3.9% → 2.3%

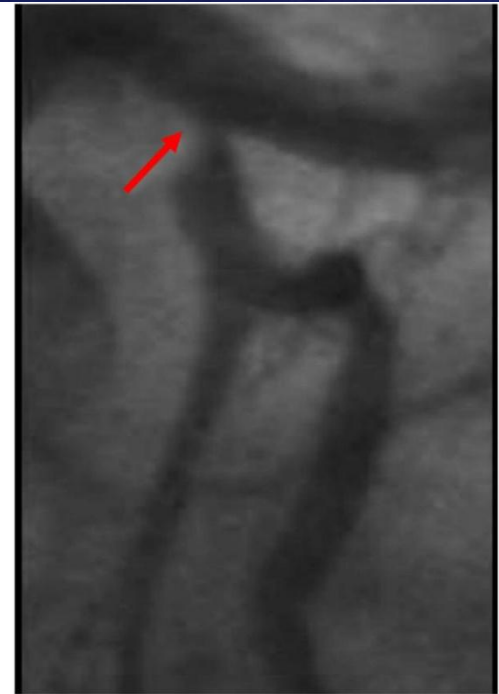
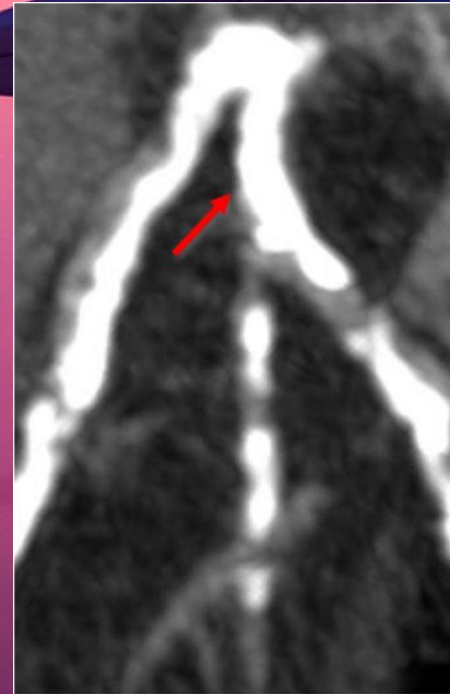
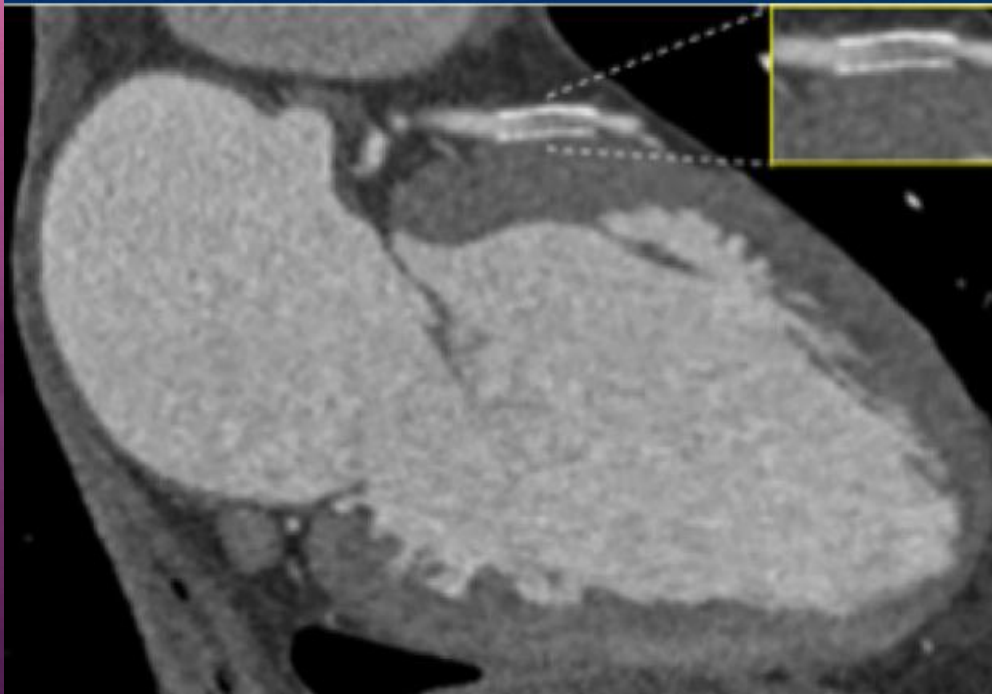








# CT-coronairen - nadelen



# CAG

Indien zeer  
hoge clinical  
likelihood



# Stressechocardiografie

Dobutamine stress echocardiography to diagnose coronary artery disease

- Induceren van ischemie door hogere demand  
Inspanning of farmacologisch
- Ook flow prox LAD en longoedeem te visualiseren
- Operator-afhankelijk



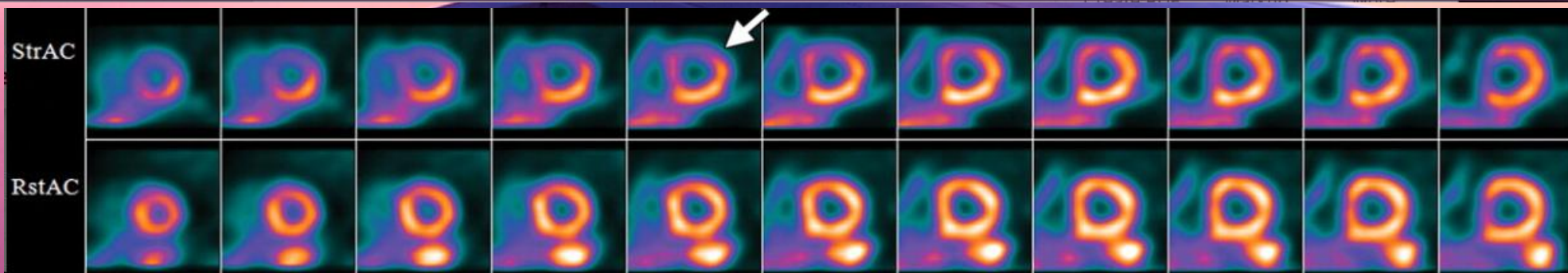
# Perfusiescintigrafie - SPECT

- Gebaseerd op myocardiale opname van radioactieve tracer
- Geadviseerd bij matig-hoog risico patienten
- Je krijgt er altijd gratis CACS bij
- Nadelen

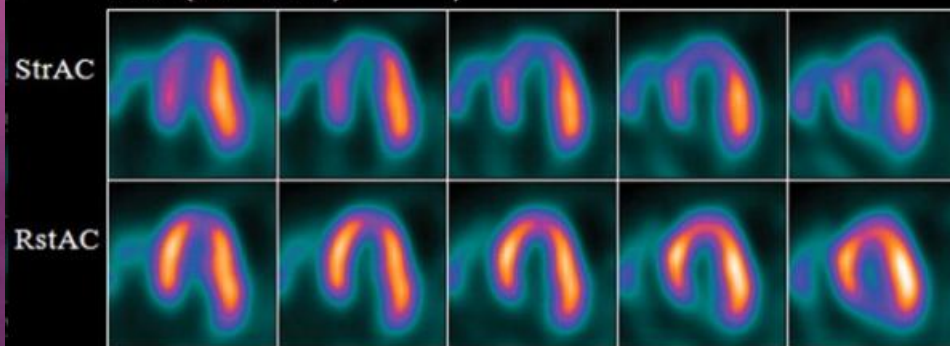
Gebalanceerde ischemie

Accuratesse tgv beperkte spatiele resolutie

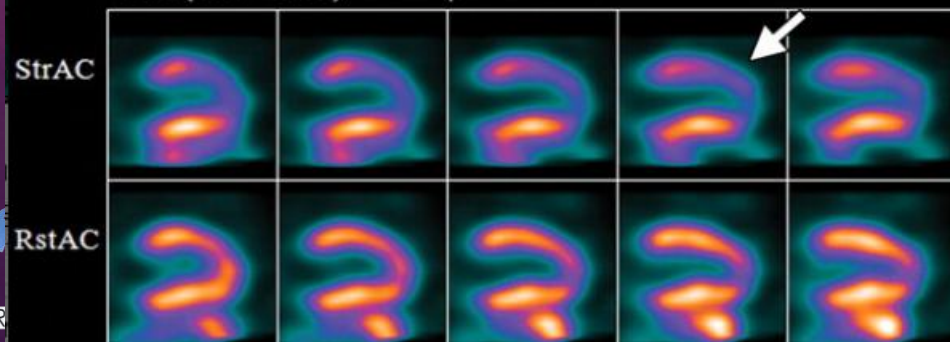




HLA (INF→ANT) —————>



VLA (SEP→LAT) —————>

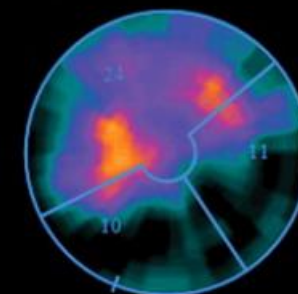
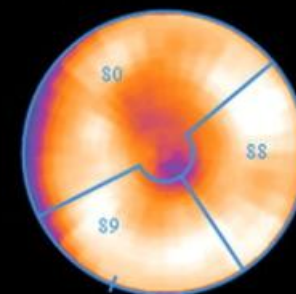
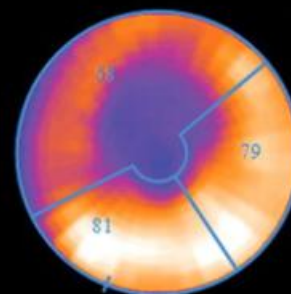


Normalized Map

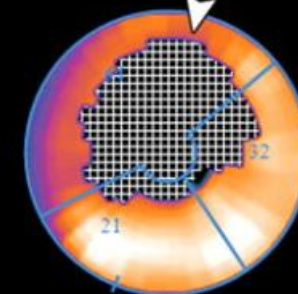
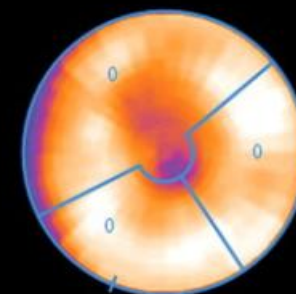
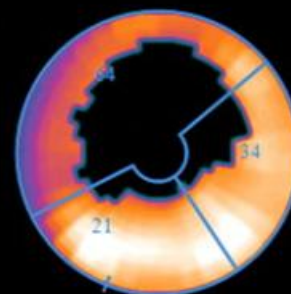
GADENO TC [ACI]

GREST TC [ACI]

Reversibility



Defect Blackout Map



# PET

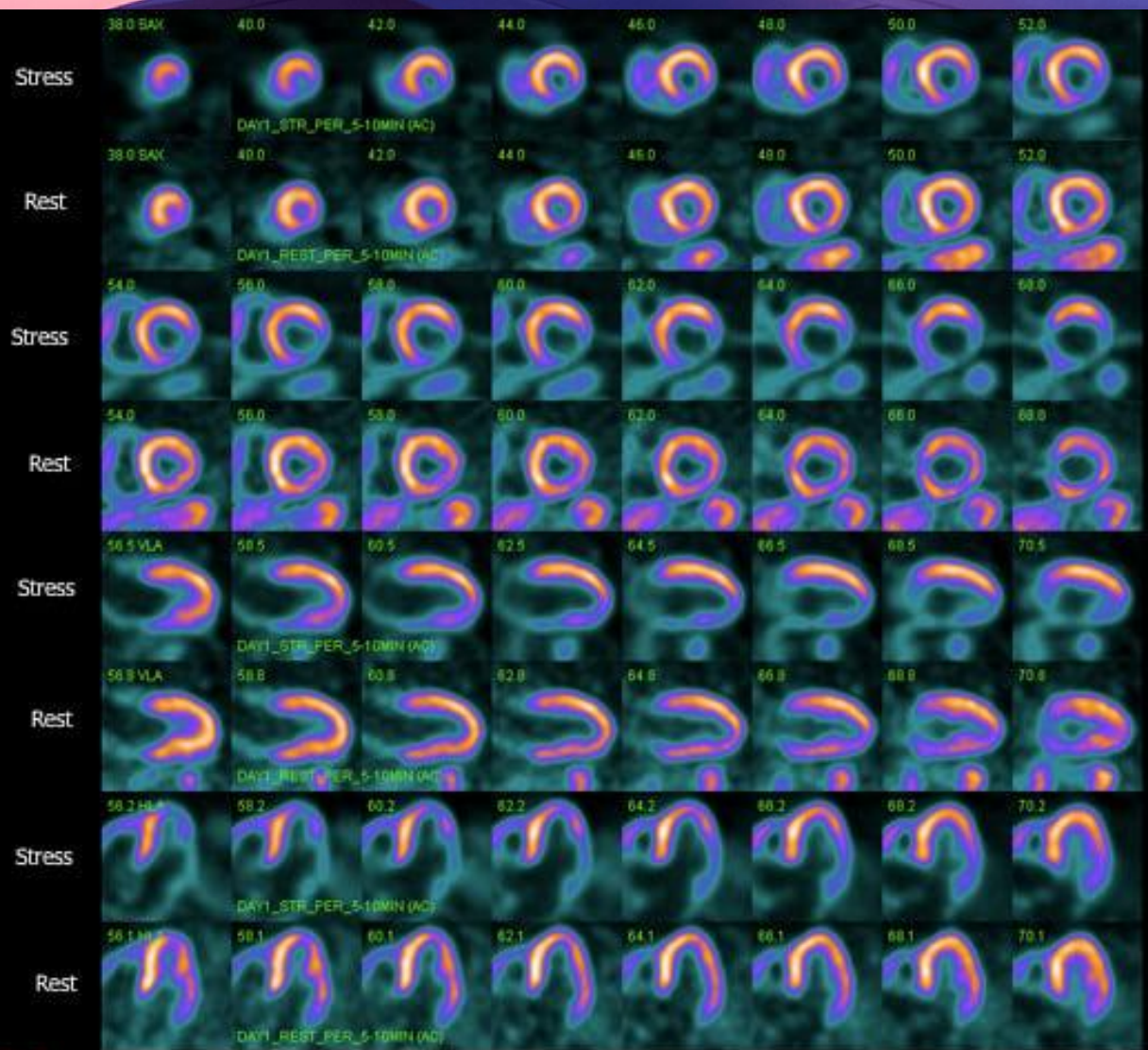
Isotopen met veel sneller verval (rubidium, flurpiridaz)

Superieure beeldkwaliteit t.o.v. SPECT

Kwantificatie van bloedflow mogelijk → dus detecteert ook 3-vatslijden

On-site productie isotopen meestal noodzakelijk





# MRI-adenosine

First-pass van contrastagens (gadolinium)

Ischemisch myocard blijft zwart in beeld

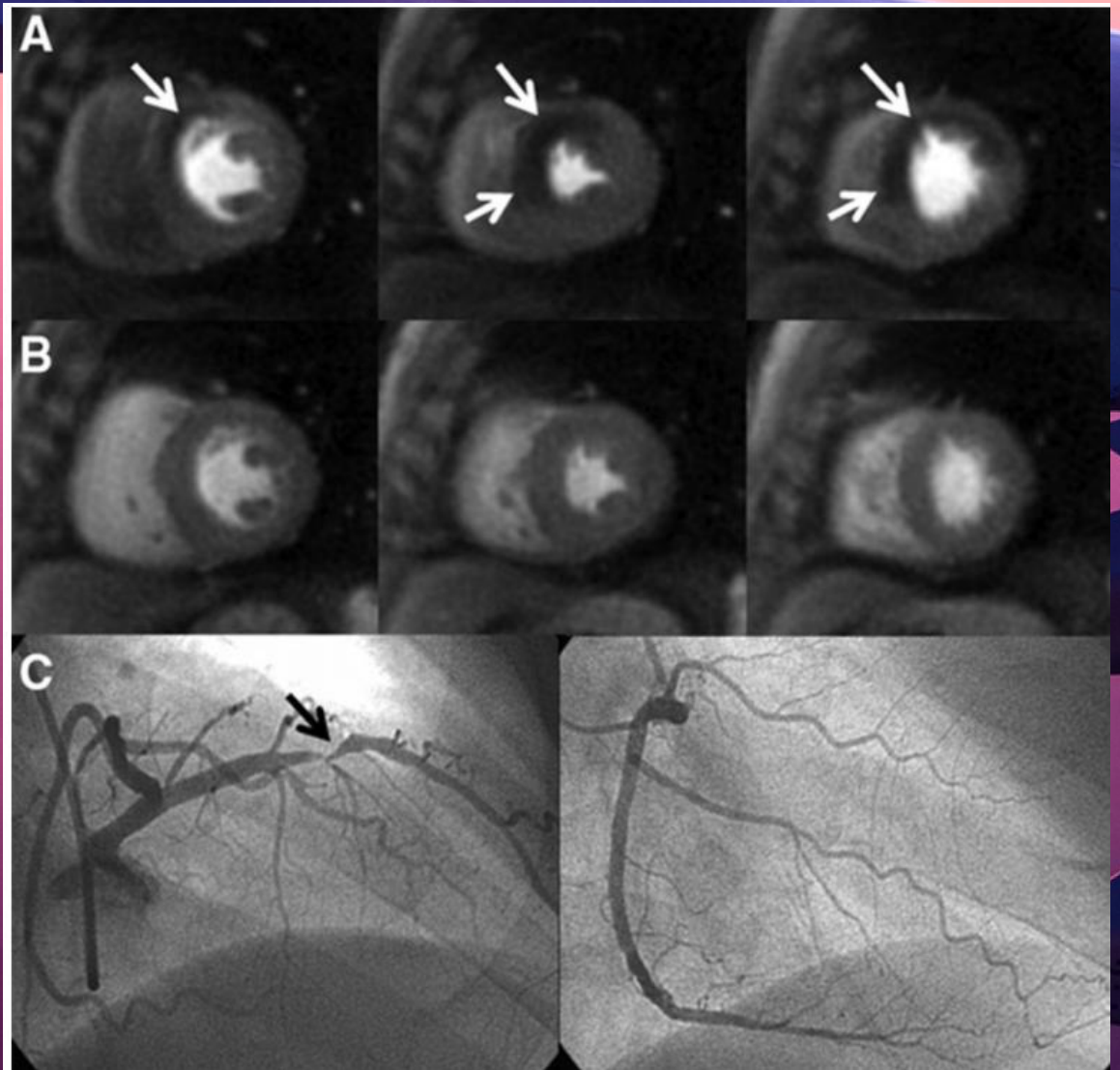
Alle andere informatie van CMR ook beschikbaar

Claustrofobie; metaal (pacemaker/klep)!



# Unlocking Heart Health: Exploring Cardiac MRI Dynamic Perfusion Imaging

Salerno, Circulation CVI 2014



# Casus 1

Man, 52 jaar, bekend met hypertensie en status na 10 pack years. Bij wielrennen heeft hij het gevoel zijn groepje niet goed bij te kunnen houden.

ECG: Normaal

Wat nu?



# Casus 1 vervolg

RF-CL: 11%  
→ X-ECG, CACS.



# Casus 2

- Vrouw, 64. Gekend met hypertensie, hypercholesterolemie, roken en preterminale nierinsufficiëntie. Vader op jonge leeftijd hartinfarct.
- Krampende pijn op de borst bij inspanning, trekt in rust snel bij
- ECG aspecifieke repolarisatiestoornissen



# Vervolg casus 2

Volgens RF-CL risico van 19%; echter nierfalen en afwijkend ECG.

Ik zou functionele test kiezen → MRI-perfusie om ook structuur en functie hart te beoordelen



# Casus 3

64-jarige man, status na STEMI voorwand 2008 w.v.  
CABG (LIMA-LAD-D, vene-RDP-RPL)

Rookt nog, BMI 29, therapietrouw is aandachtspunt

Progressieve pijn op de borst, gebruikt 3dd NTG-spray

Metoprolol, amlodipine, monocedocard recent naar 60  
opgehoogd



# Vervolg casus 3

Zeer hoge likelihood op nieuw obstructief coronairlijden  
Non-invasieve diagnostiek vermoedelijk nodeloze omweg  
CAG



# Casus 4

Asymptomatische piloot komt bij je op het spreekuur



# Casus 4

Asymptomatische piloot komt bij je op het spreekuur → ???





Aviation Medical Center



CARDIOEXPERT

## Repeat examination, over 60 years of age

---

- ✓ Medical history in combination with physical examination
- ✓ Biometrics (height, weight, waist circumference and blood pressure)
- ✓ Urine test
- ✓ Blood test (HB)
- ✓ Cholesterol analysis (afterwards on indication)
- ✓ ECG (cardiac test at rest), every 6 months
- ✓ Standard eye test
- ✓ Lung function test (peak flow)
- ✓ Standard ENT (ear, nose and throat) examination
- ✓ *Audiogram (every two years)*

# meer dan alleen ECG of X-ECG?

Bij wie?

Welke modaliteit?



# Cardiovasculaire evaluatie en luchtvaart



This project has received funding from the European Union's Horizon Europe Programme



**EASA.2022.C19**

**D-2.1 - CARDIOVASCULAR DIAGNOSTIC METHODS AND TREATMENTS  
SUITABLE FOR USE IN AEROMEDICAL FITNESS ASSESSMENTS**

## CaVD-PACE

**“Cardiovascular Diseases – Pilots and ATCOs  
Cardiovascular Evaluation”**

New diagnostic measures and treatments  
for cardiovascular diseases



**CARDIOEXPERT**

# Vragen?

