Stadtspital Zürich

Kardiologie in der Praxis

Update Ischämie-Diagnostik

Zürich, 09.04.2026
Dr. med. Muriel Wiedemann-Buser
Oberärztin meV Klinik für Kardiologie

Fallbeispiel

68-jähriger Mann mit Thoraxschmerzen

Fallvignette

- Zuweisung vom Hausarzt
- Seit 3 Monaten Thoraxschmerzen teils in Ruhe, teils bei Anstrengung, jeweils einige Minuten anhaltend, spontan regredient. → eher atypisch

Diamond-Forrester-Kriterien

1. Beklemmendes Unwohlsein auf dem Thorax oder im Hals, Kiefer, den Schultern oder dem linken Arm
2. Auftreten unter körperlicher Belastung
3. Besserung nach Sistieren der Belastung oder nach Gabe von Nitroglycerin innert 5min

→ 3 Kriterien erfüllt: **typische Angina**

→ 2 Kriterien erfüllt: **atypische Angina**

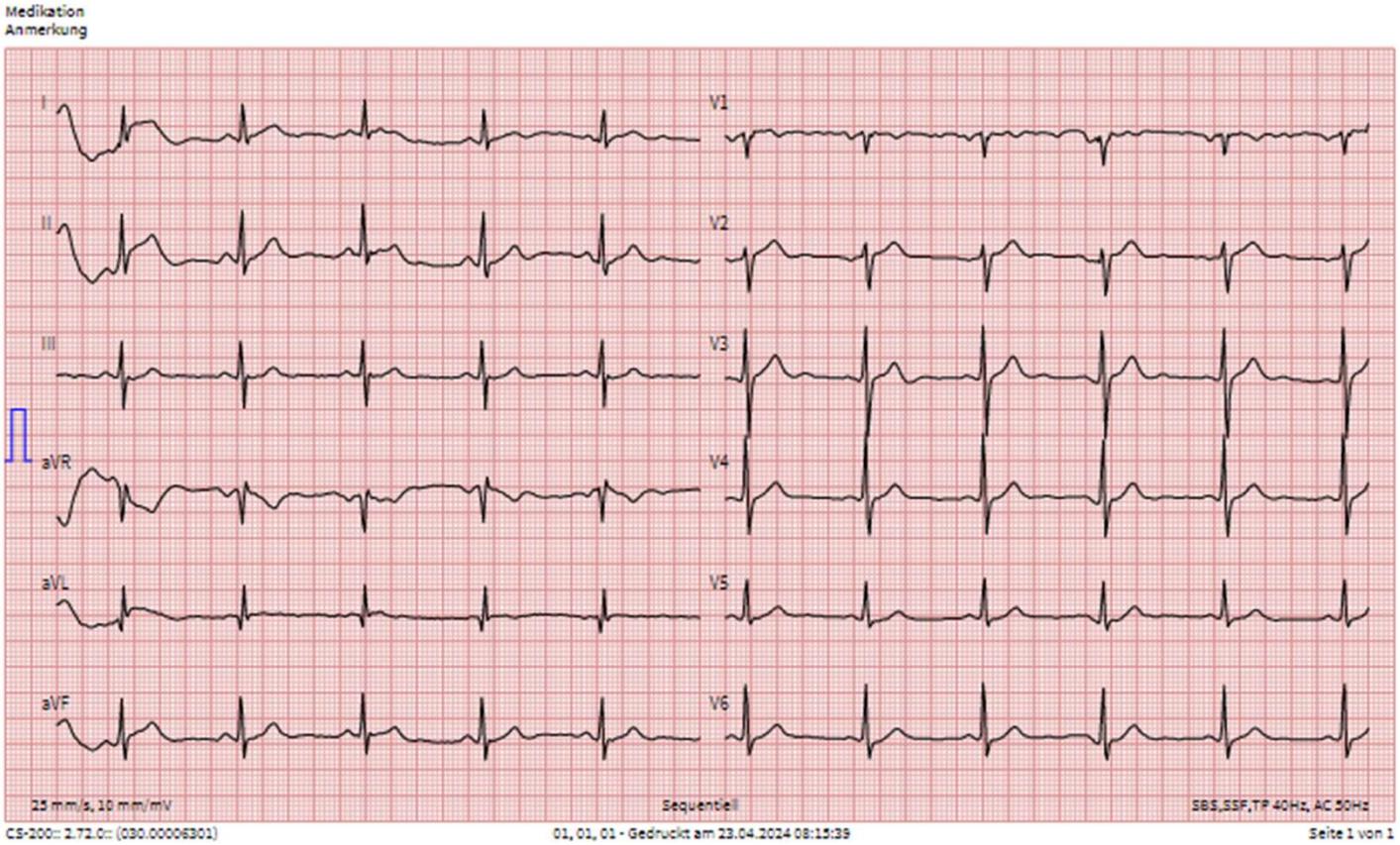
→ 0 oder 1 Kriterium erfüllt: **nicht-anginöse Schmerzen**

Diamond NEJM 1979

Fallvignette

- Medikamente: ASS cardio 100mg, Atorvastatin/Ezetimib 40/10mg, Ramipril 5mg.
- Gut kontrollierte kardiovaskuläre Risikofaktoren: BD 130-140/85mmHg, LDL 0.5mmol/l, HbA1c 5.2%, kein Nikotin.

EKG


Medikation
Anmerkung
I
II
III
aVR
aVL
aVF
V1
V2
V3
V4
V5
V6
25 mm/s, 10 mm/mV
Sequentiell
SBS,SSF,TP 40Hz, AC 50Hz
CS-200:: 2.72.0:: (030.00006301)
01, 01, 01 - Gedruckt am 23.04.2024 08:15:39
Seite 1 von 1

Ergometrie

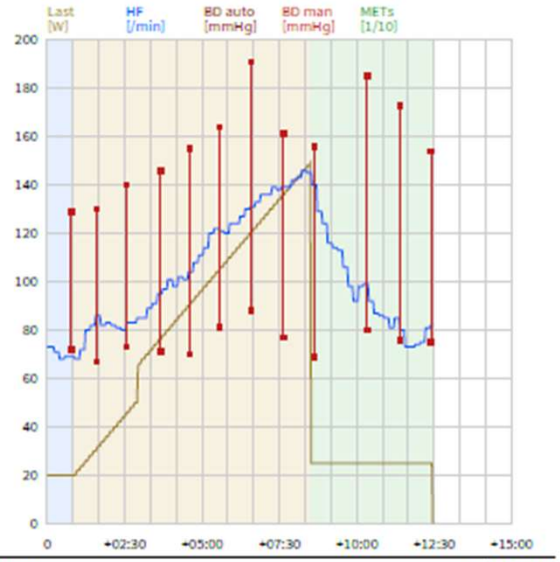
Geb.-datum	04.12.1955	Fall-Nr	41200270	Protokoll	A1-15W
Alter	068Y	Zimmer		Ergo-Gerät	--
Geschlecht	Männlich	Auftr.-ID		BD-Rekorder	--
Ethnie	Nicht definiert	Auftragg.			
Grösse	173 cm	Zuw. Arzt		Ruhe-HF	68 /min
Gewicht	66 kg	Geräte-ID	CS200ERG	Ruhe-BD	129 / 72 mmHg
Medikation					
Anmerkung					

Validiert von User für KISIM Absprung - 23.04.2024 08:54:20

Vorstufe	--:-- min	Max. Last	149 W (111% of 134 W)	Max. HF	146 /min (96% of 152 /min)
Aufwärmen	2:26:39 min	Max. METs	--	Max. BD	191 / 88 mmHg
Belastung	07:39 min	Leistungsge...	2.3 W/kg		
Erholung	03:57 min			Min. BD x HF	87 mmHg/min
Gesamt	12:28 min	PWC 130	-- W (-- W/kg)	Max. BD x HF	-- mmHg/min
		PWC 150	157 W (2.38 W/kg)	DP-Faktor	--
		PWC 170	200 W (3.03 W/kg)		
Abbruch	--				

Stufe	Phase [mm:ss]	Last [W]	HF [/min]	BD [mmHg]	J40 VS [mm]	J40 VS [mV/s]	RPE	Laktat [mmol/l]	VES	SpO2 [%]
Aufwärmen	00:52	0	68	129/72	0.2	0.1	0	--	--	--
Belastung 1	01:00	35	82	130/67	0.6	0.0	0	--	--	--
Belastung 2	02:00	50	85	140/73	0.4	0.0	0	--	--	--
Belastung 3	02:03	50	84	--	0.3	0.0	0	--	--	--
Belastung 4	03:02	80	101	146/71	0.4	-0.1	0	--	--	--
Belastung 5	04:02	95	111	155/70	0.0	-0.3	0	--	--	--
Belastung 6	05:02	110	124	164/81	-0.4	-0.5	0	--	--	--
Belastung 7	06:02	125	135	191/88	-1.3	-0.2	0	--	--	--
Belastung 8	07:02	140	142	161/77	-1.8	0.1	0	--	--	--
Belastung 9	07:39	149	143	--	-2.4	-0.4	0	--	--	--
Erholung 1	01:00	25	107	156/69	-0.4	-0.3	0	--	--	--
Erholung 2	02:00	25	89	185/80	-0.1	-0.3	0	--	--	--
Erholung 3	03:00	25	72	173/76	-0.3	0.1	0	--	--	--
Testende	03:57	25	81	154/75	-0.2	0.1	0	--	--	--

STmax (VS) -2.4 mm | -0.4 mV/s @ +08:24



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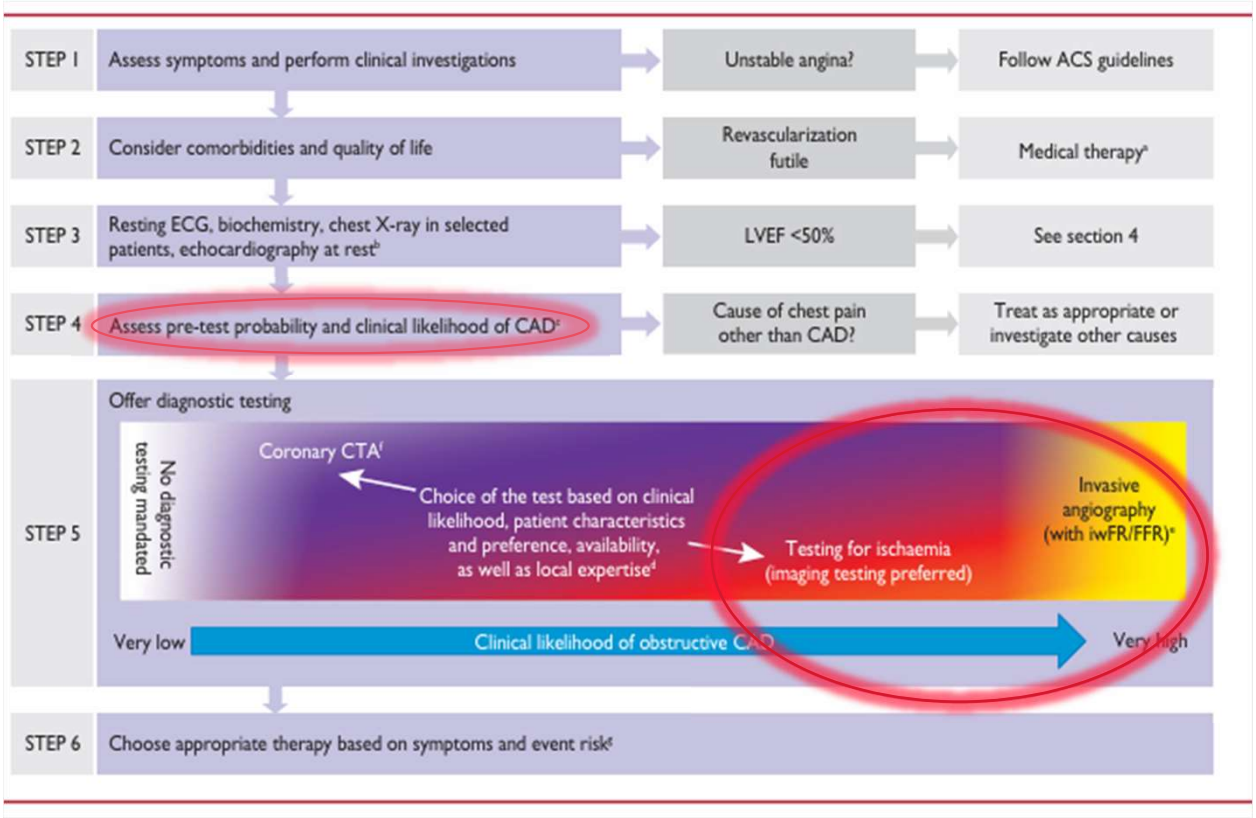
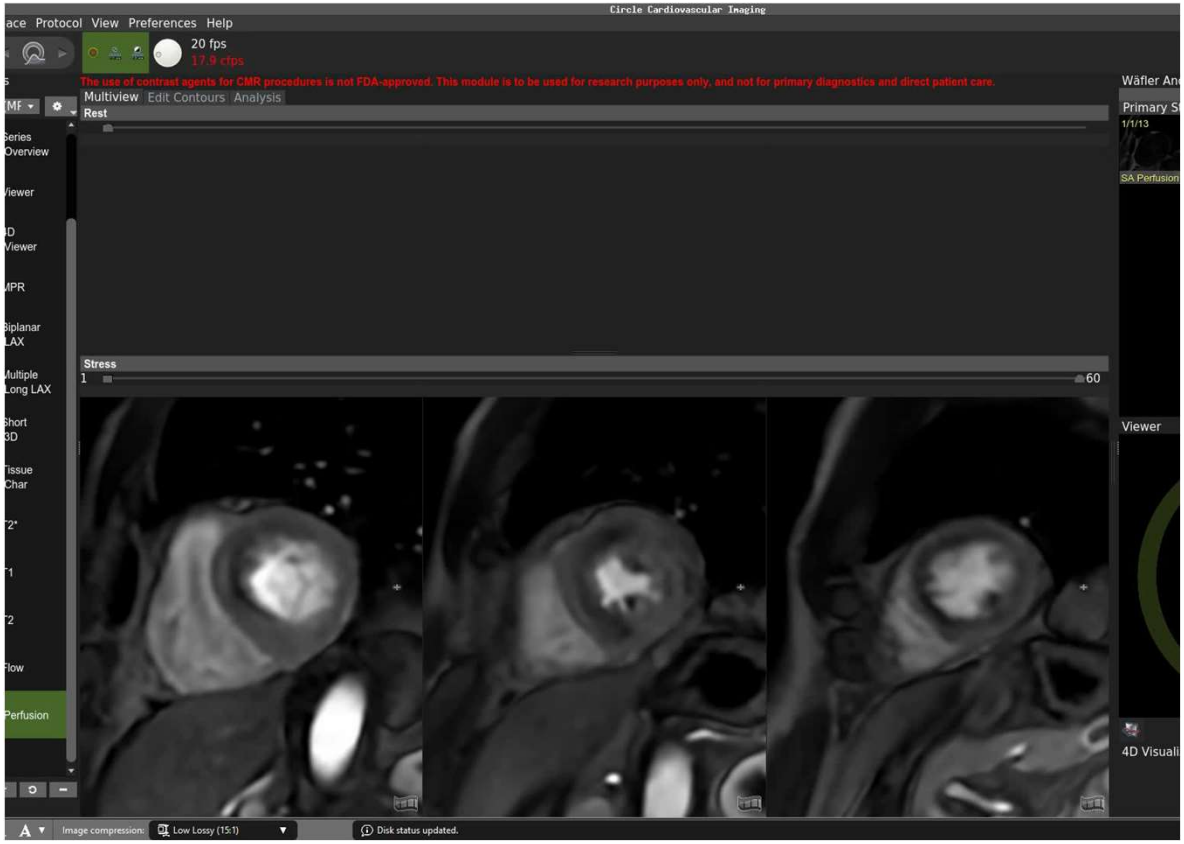
Wie weiter?

Nicht-invasiver Ischämietest vs. Koronarangiographie

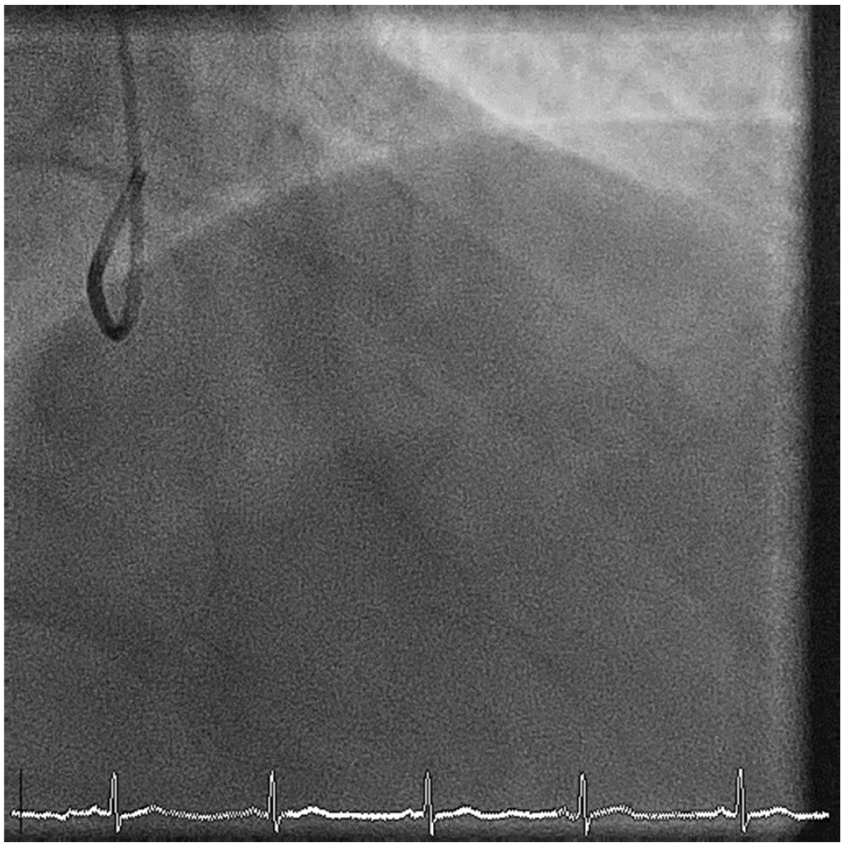


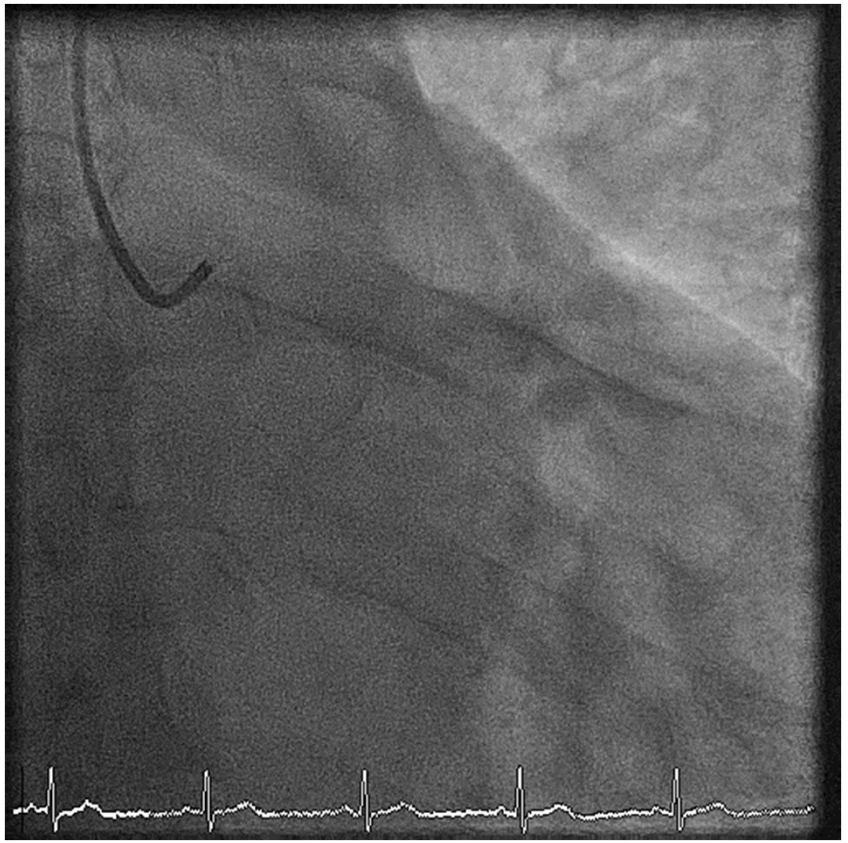
ESC Guidelines "Chronic coronary syndromes" 2019

Kardiales Stress-MRI

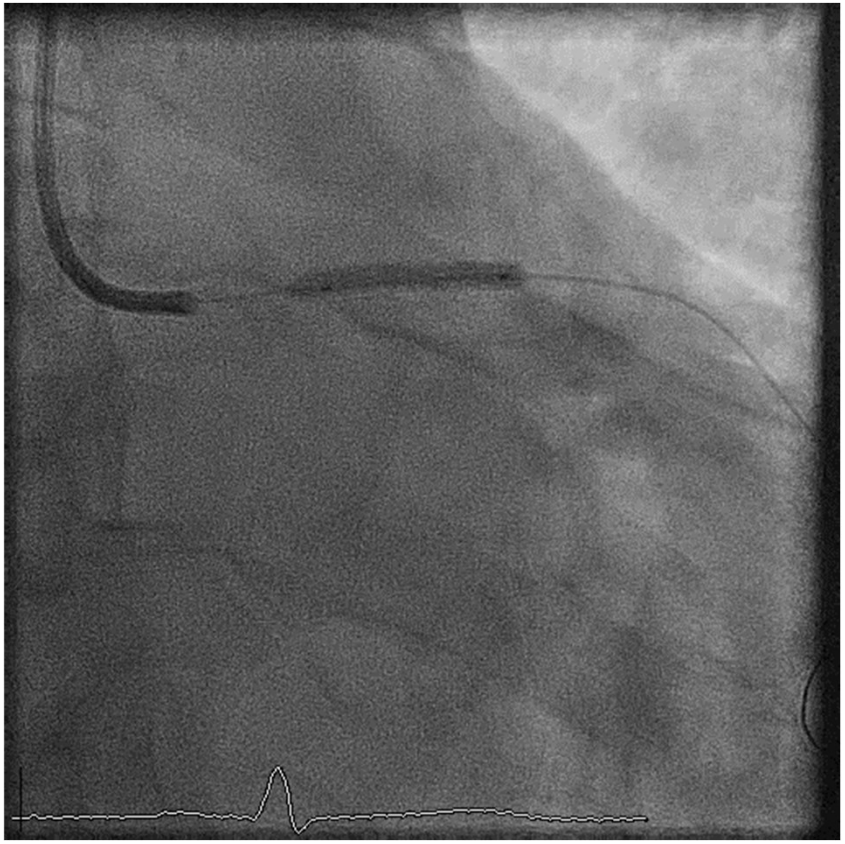


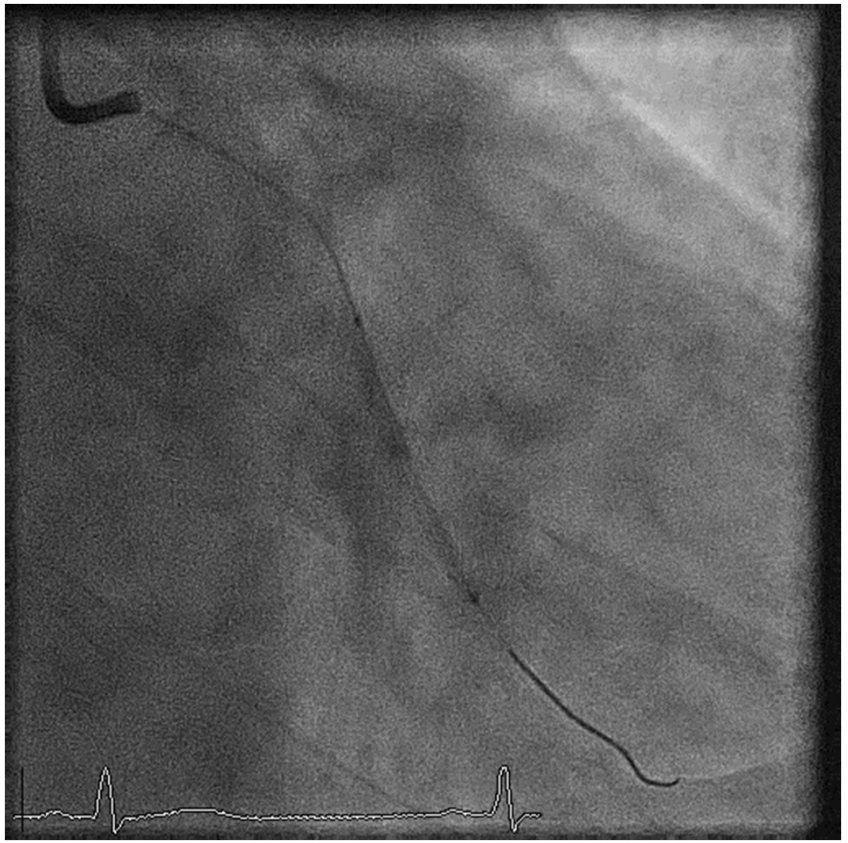
Koronarangiographie



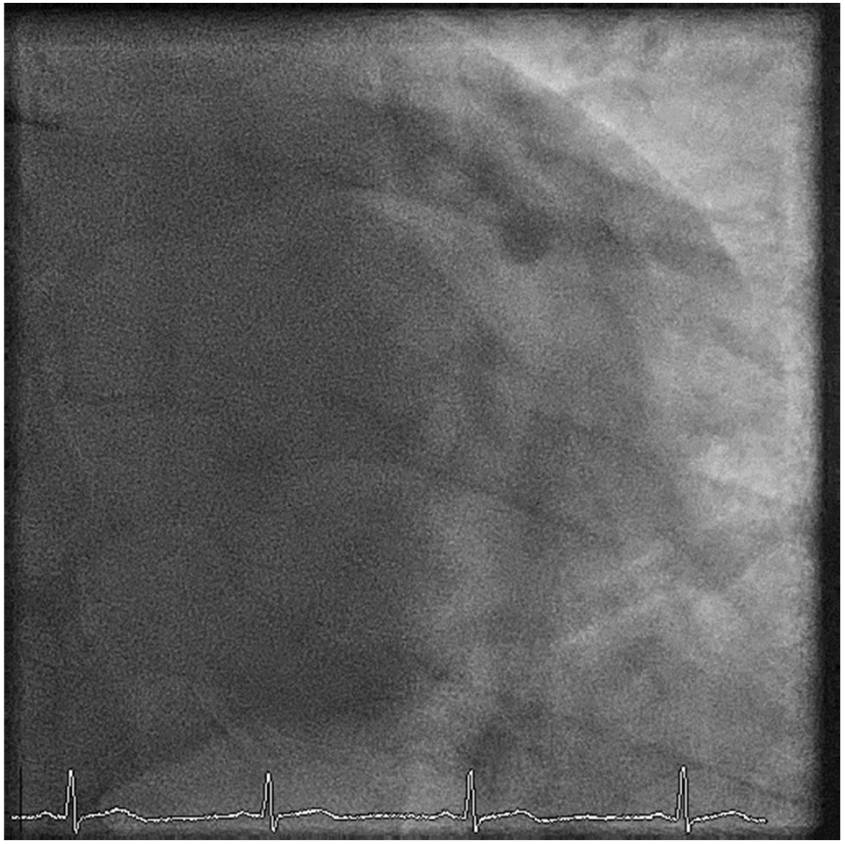


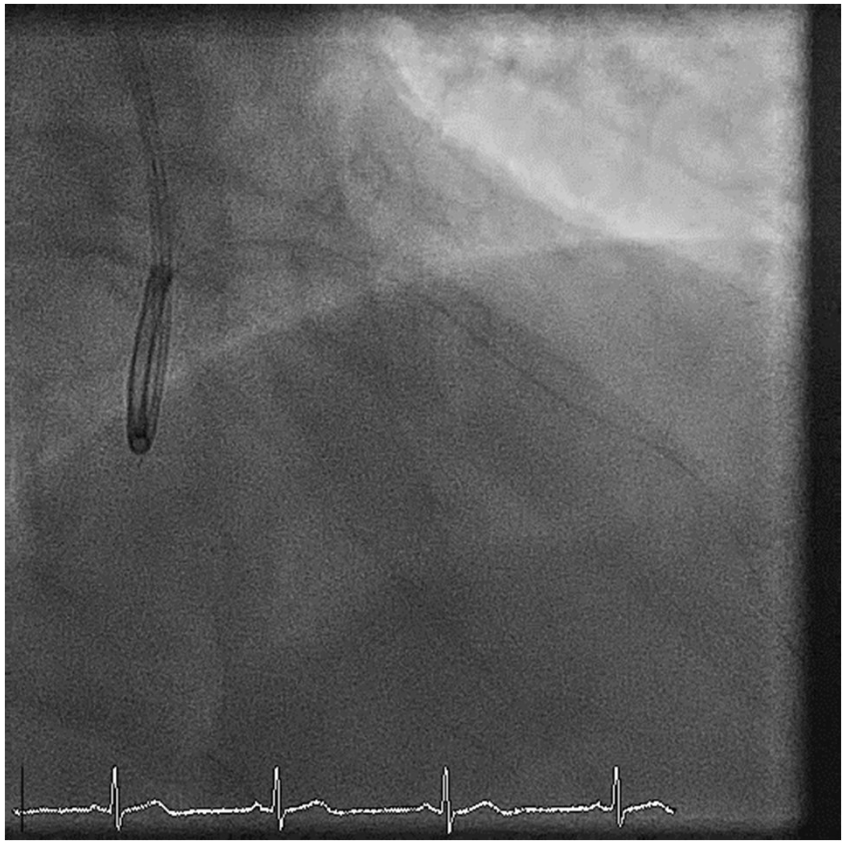
Koronarangiographie





Koronarangiographie

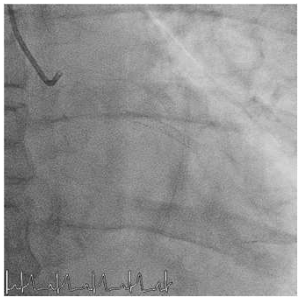




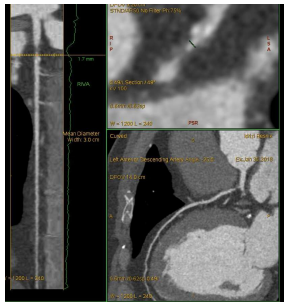
- PCI/DES proximaler RIVA, Drug coated Balloon 2. Marginalast
- Zusätzlich Plavix für 6 Monate

Ischämie-Diagnostik 2026

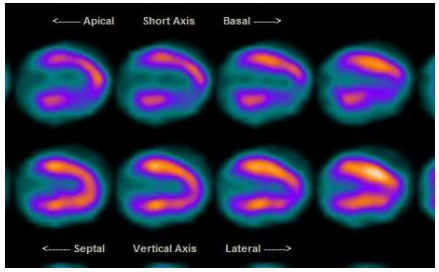
Ergometrie



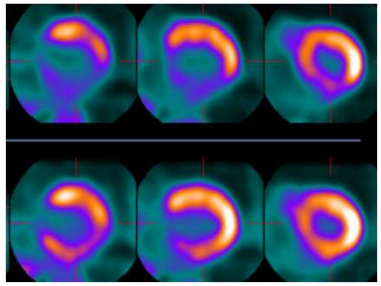
Koro



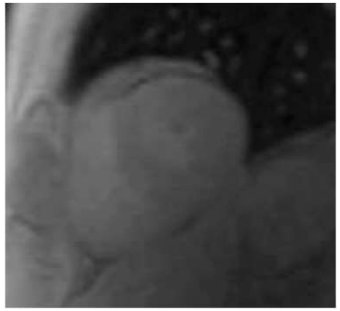
Koro-CT



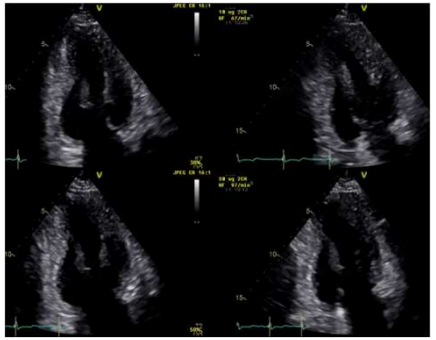
SPECT



PET



Stress-MRI



Stressecho

ESC European Society of Cardiology
European Heart Journal (2024) **45**, 3415–3537
https://doi.org/10.1093/eurheartj/ehae177

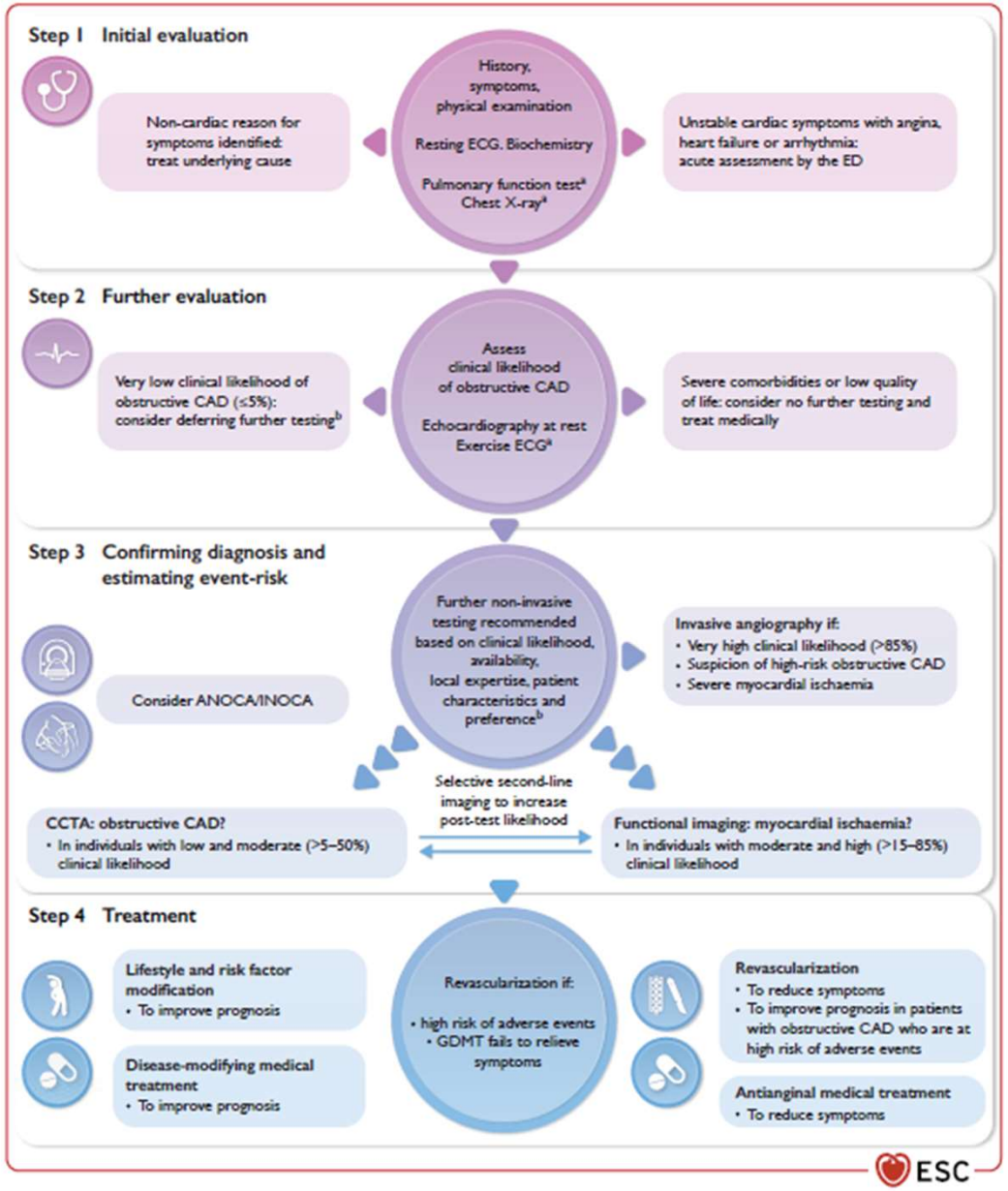
2024 ESC Guidelines for the management of chronic coronary syndromes

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

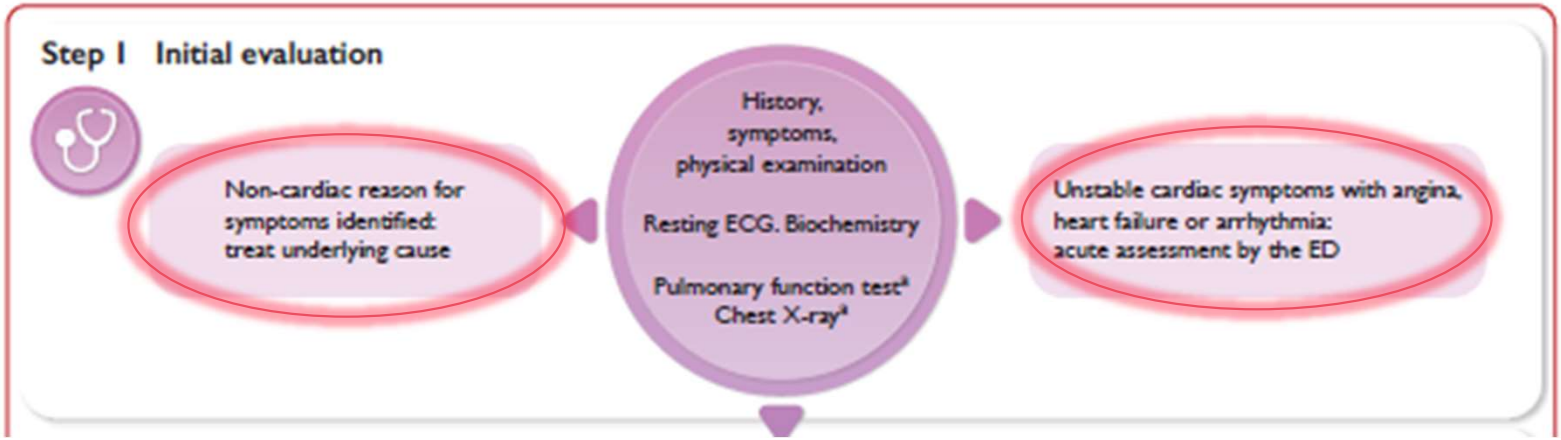
Endorsed by the European Association for Cardio-Thoracic Surgery (EACTS)

Authors/Task Force Members: Christiaan Vrints *†, (Chairperson) (Belgium), Felicita Andreotti *†, (Chairperson) (Italy), Konstantinos C. Koskinas‡, (Task Force Co-ordinator) (Switzerland), Xavier Rossello ‡, (Task Force Co-ordinator) (Spain), Marianna Adamo (Italy), James Ainslie (United Kingdom), Adrian Paul Banning (United Kingdom), Andrzej Budaj (Poland), Ronny R. Buechel (Switzerland), Giovanni Alfonso Chiariello (Italy), Alaide Chieffo (Italy), Ruxandra Maria Christodorescu (Romania), Christi Deaton (United Kingdom), Torsten Doenst [1] (Germany), Hywel W. Jones (United Kingdom), Vijay Kunadian (United Kingdom), Julinda Mehilli (Germany), Milan Milojevic [1] (Serbia), Jan J. Piek (Netherlands), Francesca Pugliese (United Kingdom), Andrea Rubboli (Italy), Anne Grete Semb (Norway), Roxy Senior (United Kingdom), Jurrien M. ten Berg (Netherlands), Eric Van Belle (France), Emeline M. Van Craenenbroeck (Belgium), Rafael Vidal-Perez (Spain), Simon Winther (Denmark), and ESC Scientific Document Group

Algorithmus



ESC-Guidelines CCS 2024

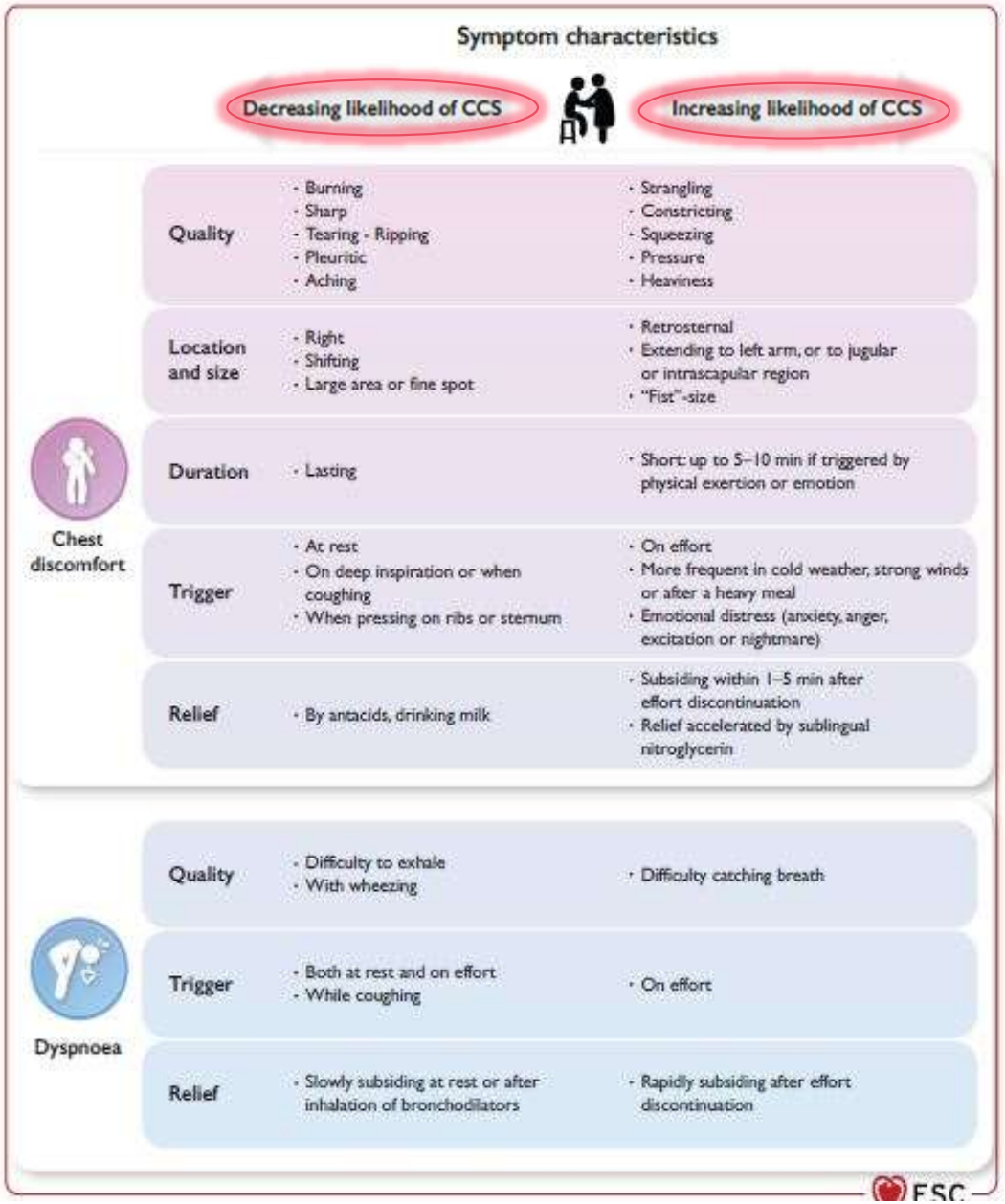

Step 1 Initial evaluation
Non-cardiac reason for symptoms identified: treat underlying cause
History, symptoms, physical examination
Resting ECG. Biochemistry
Pulmonary function test[a]
Chest X-ray[a]
Unstable cardiac symptoms with angina, heart failure or arrhythmia: acute assessment by the ED

– Nur 10-25% mit Vd. a. CCS haben typische Angina
– 57-78% haben atypische Beschwerden
– 10-15% haben Anstrengungsdyspnoe

Douglas PS, Hoffmann U, Patel MR, Mark DB, Al-Khalidi HR, Cavanaugh B, *et al.* Outcomes of anatomical versus functional testing for coronary artery disease. *N Engl J Med* 2015;**372**:1291–300. https://doi.org/10.1056/NEJMoa1415516

– PRECISE: typisch vs. atypisch hatten ähnliche 1 Jahres-Outcomes, dh limitierter prognostischer Wert

Douglas PS, Nanna MG, Kelsey MD, Yow E, Mark DB, Patel MR, *et al.* Comparison of an initial risk-based testing strategy vs usual testing in stable symptomatic patients with suspected coronary artery disease: the PRECISE randomized clinical trial. *JAMA Cardiology* 2023;**8**:904–14. https://doi.org/10.1001/jamacardio.2023.2595

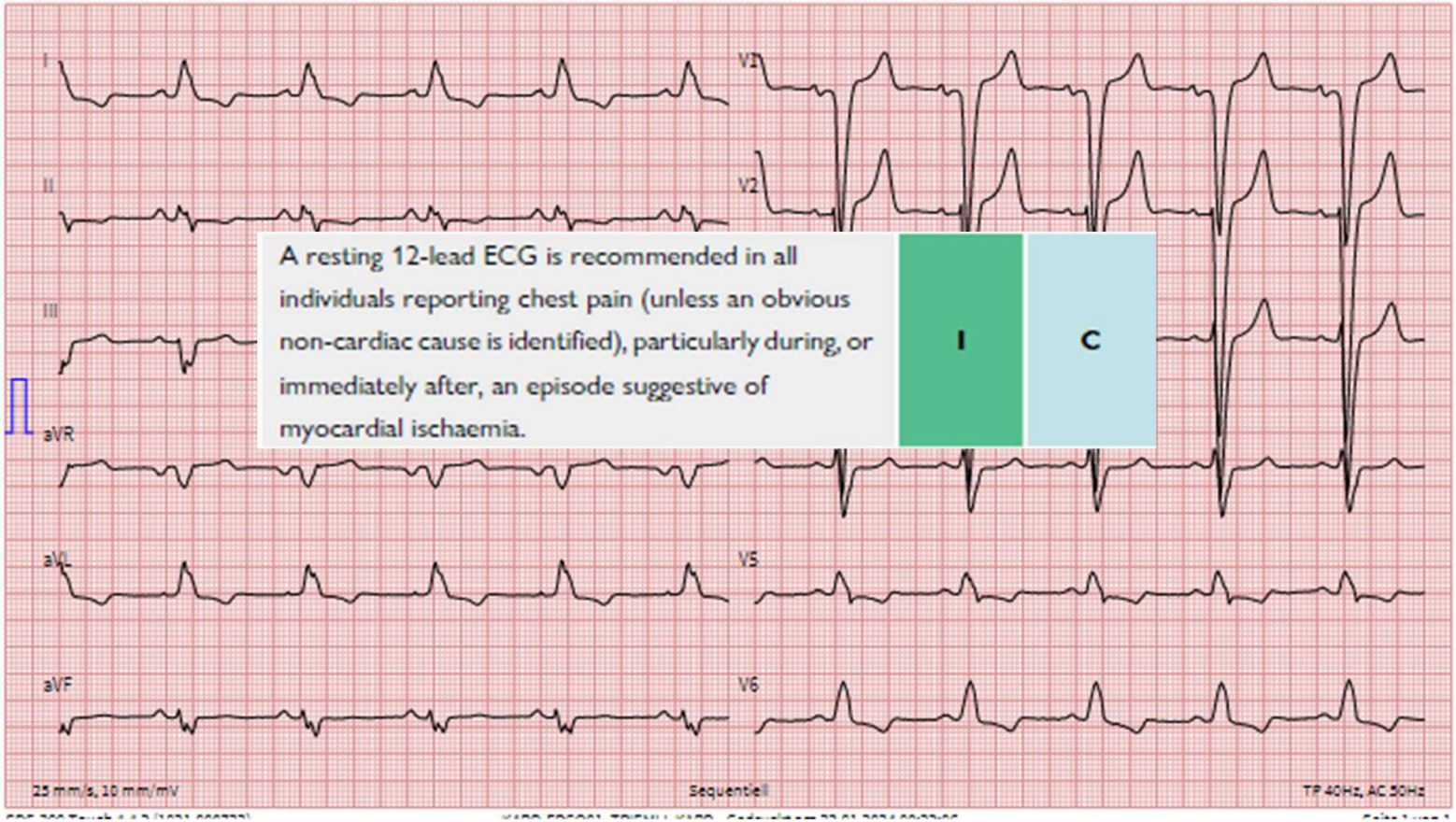

Symptom characteristics
Decreasing likelihood of CCS
Increasing likelihood of CCS
Chest discomfort
Quality
- Burning
- Sharp
- Tearing - Ripping
- Pleuritic
- Aching
- Strangling
- Constricting
- Squeezing
- Pressure
- Heaviness
Location and size
- Right
- Shifting
- Large area or fine spot
- Retrosternal
- 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, excitation 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
ESC

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)

EKG

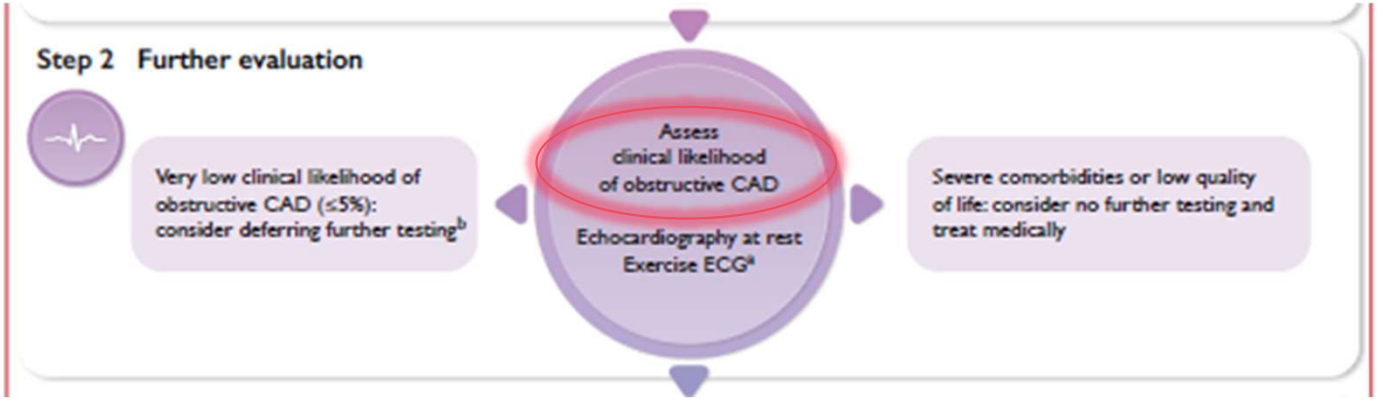

I
II
III
aVR
aVL
aVF
V1
V2
V5
V6
A resting 12-lead ECG is recommended in all individuals reporting chest pain (unless an obvious non-cardiac cause is identified), particularly during, or immediately after, an episode suggestive of myocardial ischaemia.
I
C
25 mm/s, 10 mm/mV
Sequentiell
TP 40Hz, AC 50Hz

Labor

Recommendations	Class[a]	Level[b]
The following blood tests are recommended in all individuals to refine risk stratification, diagnose comorbidities, and guide treatment:		
• lipid profile including LDL-C;[64,128]	I	A
• full blood count (including haemoglobin);[129–133]	I	B
• creatinine with estimation of renal function;[134]	I	B
• glycaemic status with HbA1c and/or fasting plasma glucose.[16,86,135,136]	I	B
In patients with suspected CCS, it is recommended to assess thyroid function at least once.[137,138]	I	B
Additionally, hs-CRP and/or fibrinogen plasma levels should be considered.[109–118,121,125]	IIa	B

CCS, chronic coronary syndrome; HbA1c, glycated haemoglobin; hs-CRP, high-sensitivity C-reactive protein; LDL-C, low-density lipoprotein cholesterol.
[a]Class of recommendation.
[b]Level of evidence.

Algorithmus



Vortestwahrscheinlichkeit

2013

	Typical angina		Atypical angina		Non-anginal pain	
Age	Men	Women	Men	Women	Men	Women
30–39	59	28	29	10	18	5
40–49	69	37	38	14	25	8
50–59	77	47	49	20	34	12
60–69	84	58	59	28	44	17
70–79	89	68	69	37	54	24
>80	93	76	78	47	65	32

2019

	Typisch		Atypisch		Nicht-anginös		Dyspnoe	
Alter	m	w	m	w	m	w	m	w
30-39	3%	5%	4%	3%	1%	1%	0%	3%
40-49	22%	10%	10%	6%	3%	2%	12%	2%
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%

ESC-Guidelines SCAD 2013
ESC-Guidelines CCS 2019

Vortestwahrscheinlichkeit

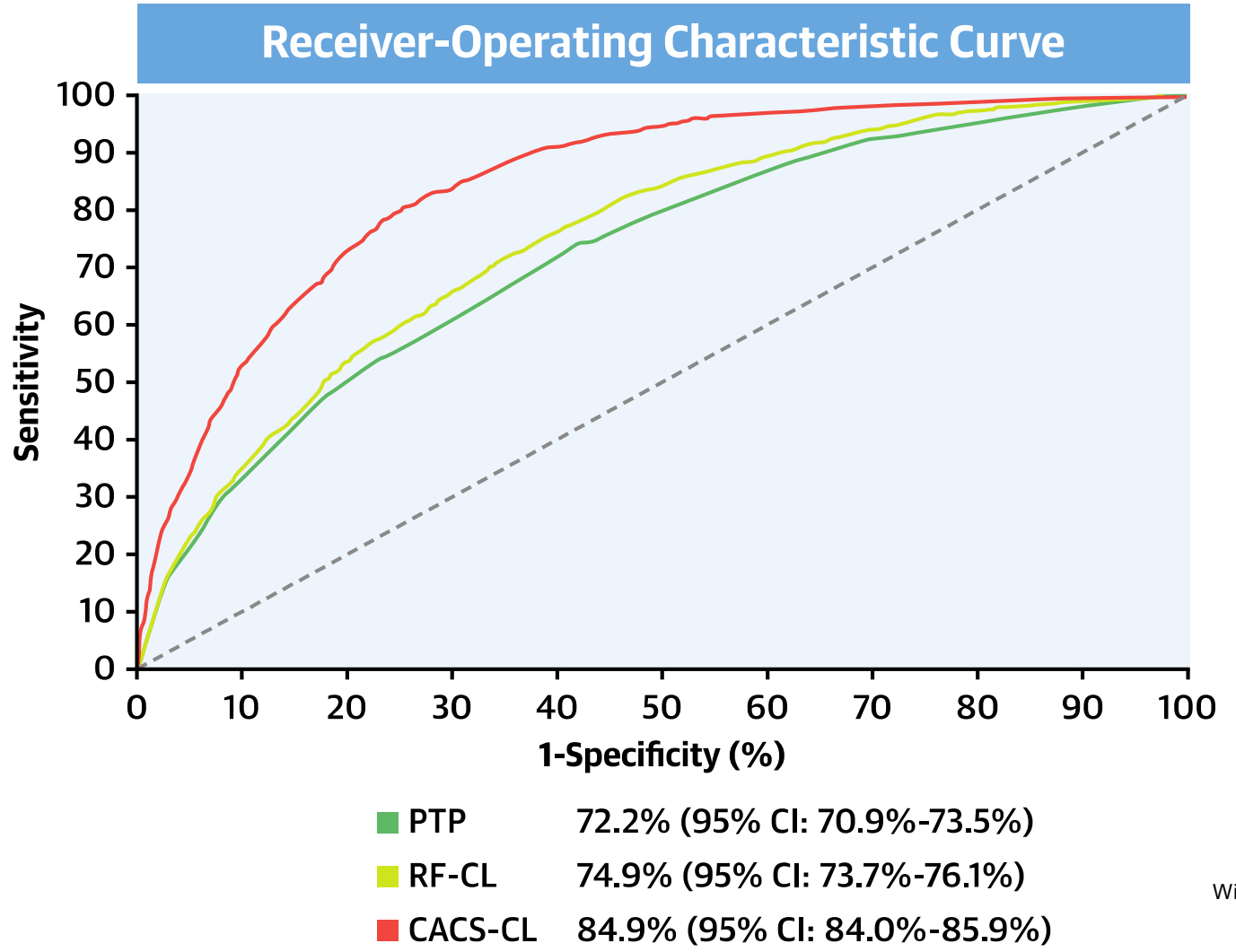
Guidelines 2024: **Risk-Factor-weighted Clinical Likelihood (RF-CL) model**

Risk-Factor-weighted Clinical Likelihood (RF-CL)

- Geschlecht
- Alter
- Symptome
- Erhebung der **kardiovaskulären Risikofaktoren** (Nikotin, Familienanamnese, Lipide, Hypertonie, Diabetes)
- Erhebung von Komorbiditären: Niereninsuffizienz, pAVK, cerebrovaskuläre Krankheit, COPD, rheumatologische Erkrankungen

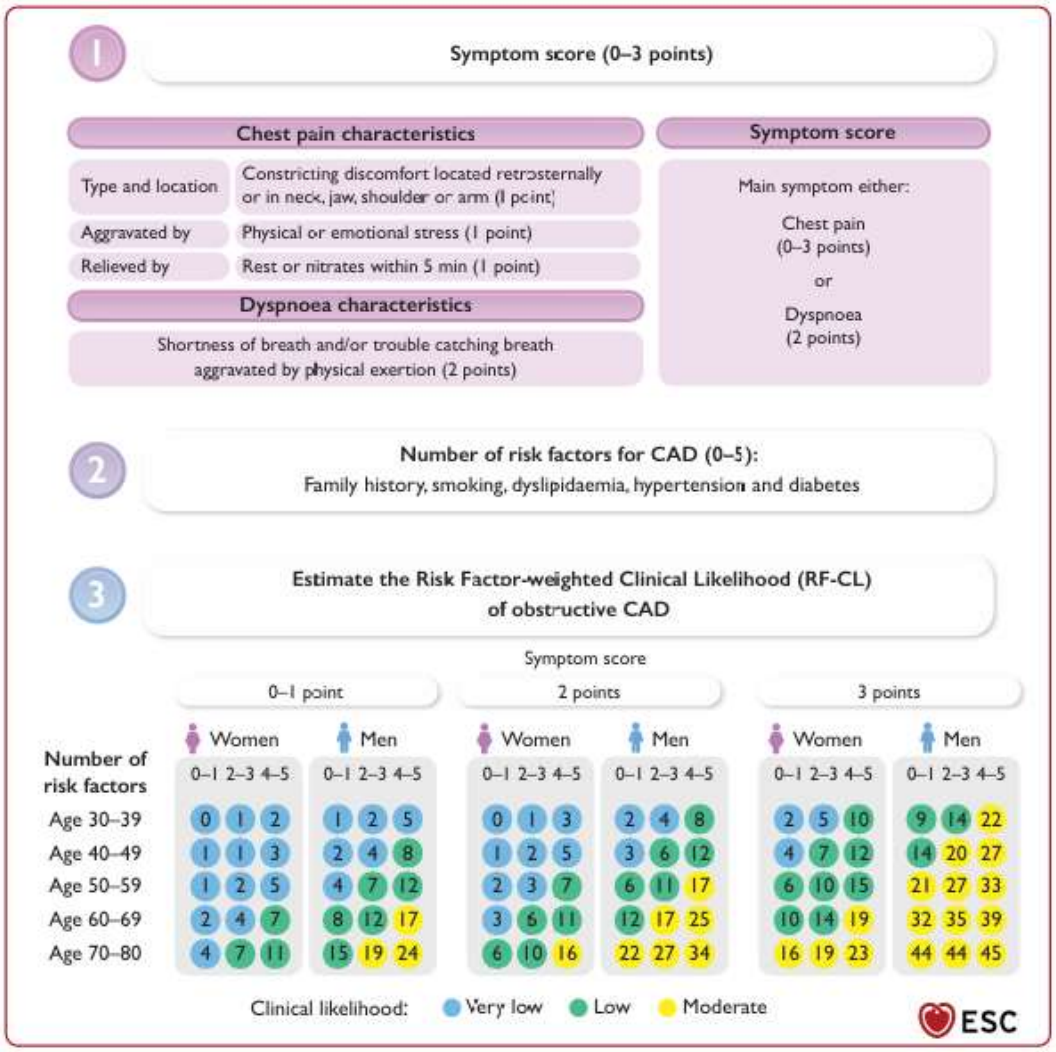
Algorithmus

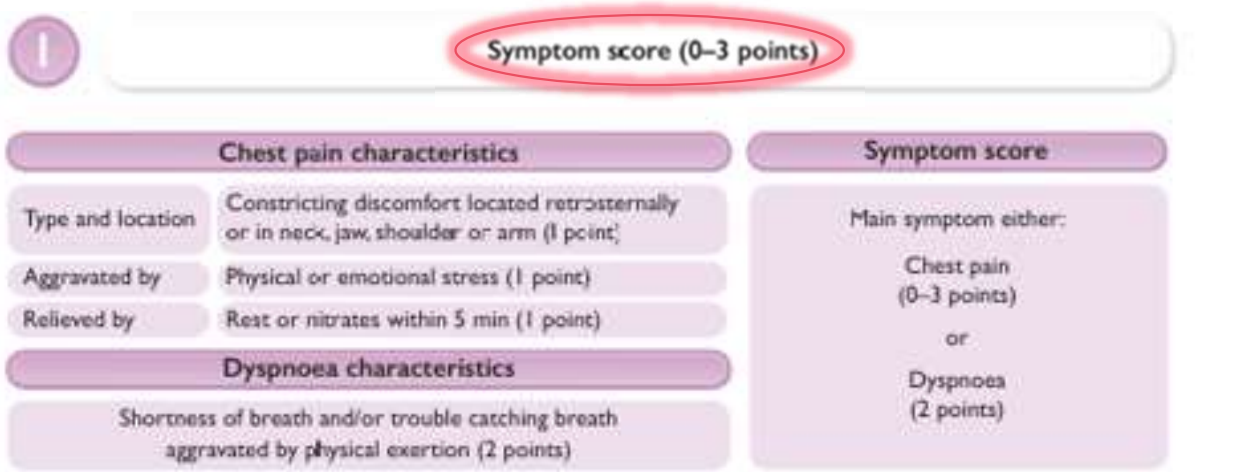
B

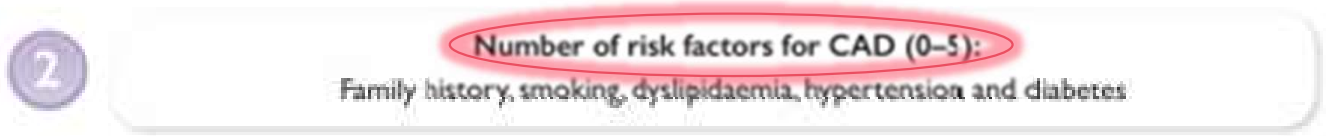


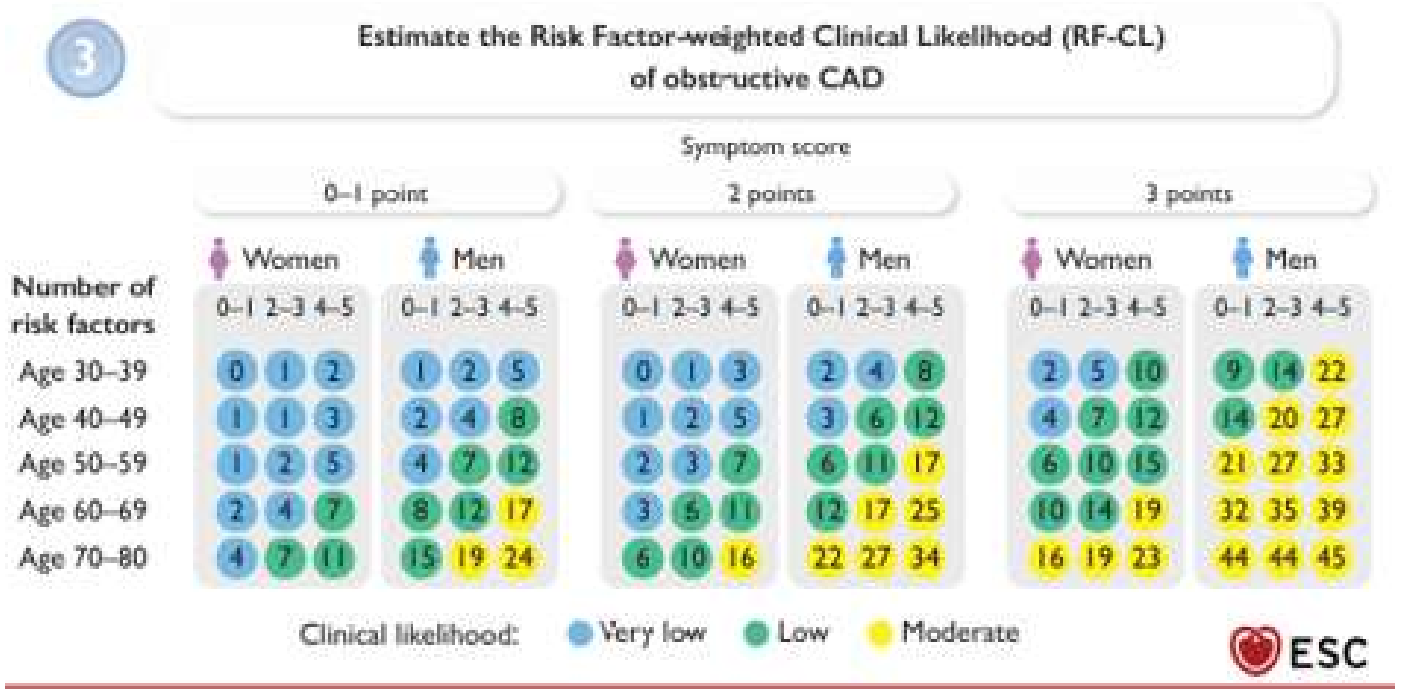
Winther JACC 2020

Algorithmus




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
Symptom score
0–1 point
2 points
3 points
Women
Men
Number of risk factors
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
ESC

Vortestwahrscheinlichkeit

2013

	Typical angina		Atypical angina		Non-anginal pain	
Age	Men	Women	Men	Women	Men	Women
30–39	59	28	29	10	18	5
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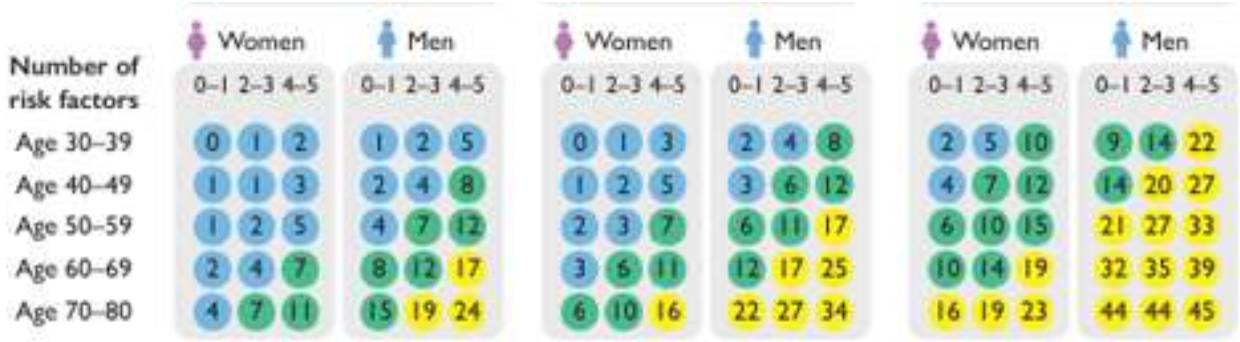
70–79	89	68	69	37	54	24
>80	93	76	78	47	65	32

2019

	Typisch		Atypisch		Nicht-anginös		Dyspnoe	
Alter	m	w	m	w	m	w	m	w
30-39	3%	5%	4%	3%	1%	1%	0%	3%
40-49	22%	10%	10%	6%	3%	2%	12%	2%
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%

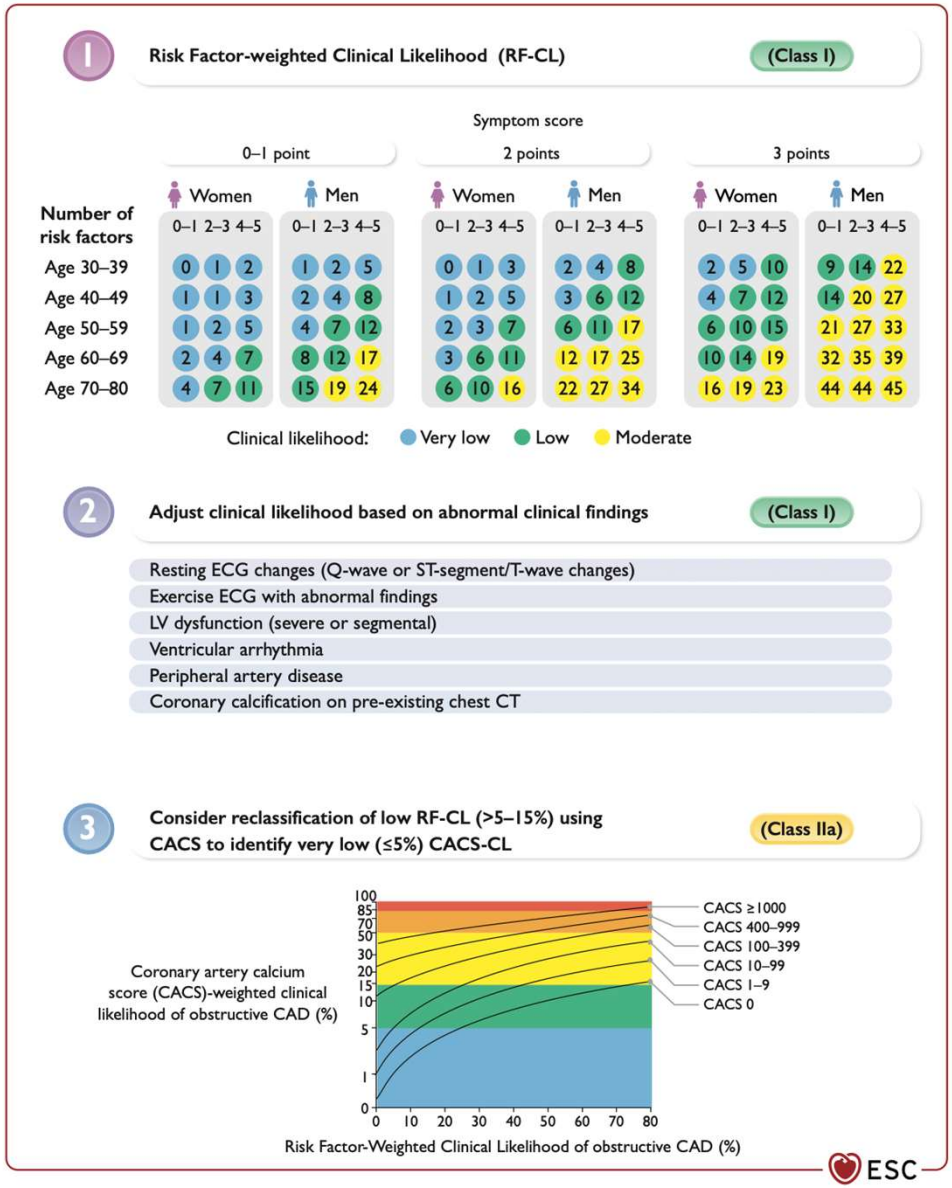
2024



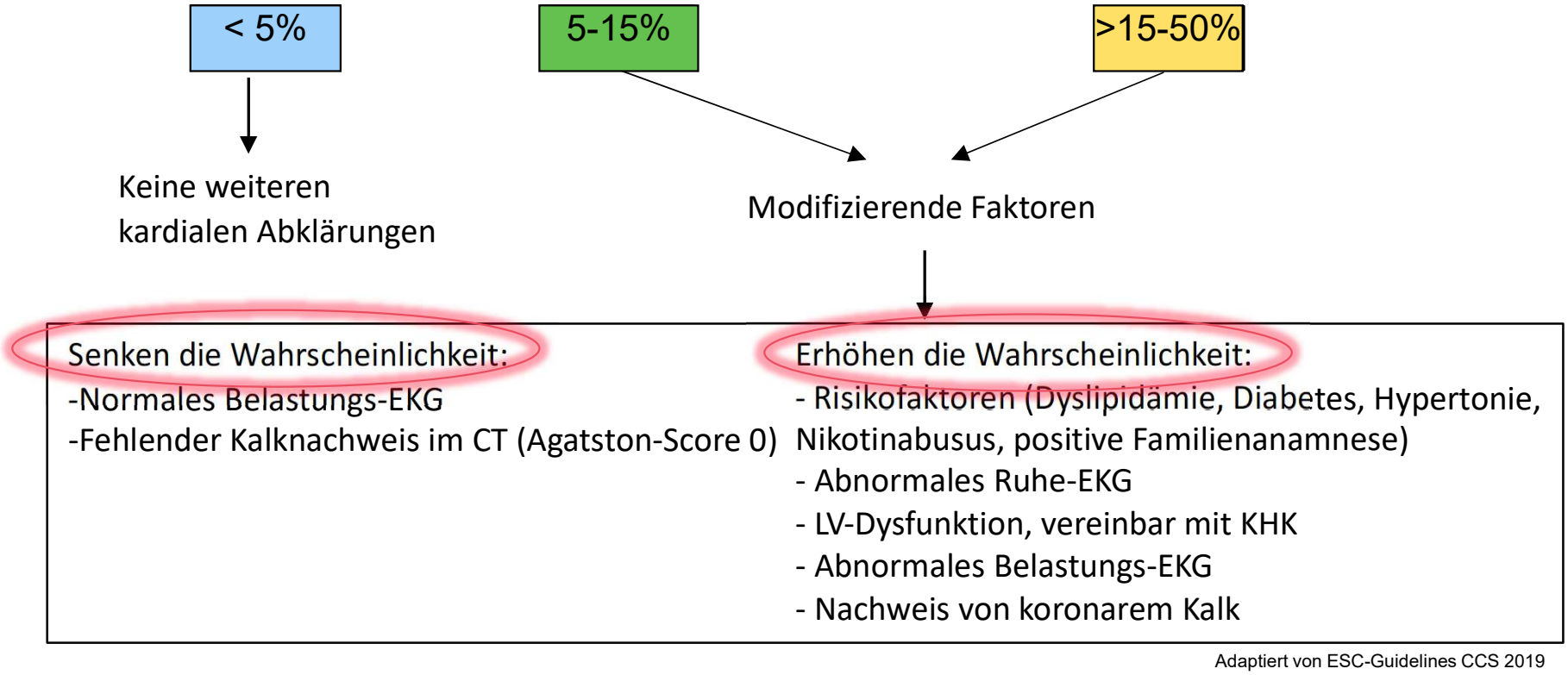
Algorithmus

Recommendations	Class[a]	Level[b]
It is recommended to estimate the pre-test likelihood of obstructive epicardial CAD using the Risk Factor-weighted Clinical Likelihood model.[139,140,142,143,161,162]	I	B
It is recommended to use additional clinical data (e.g. examination of peripheral arteries, resting ECG, resting echocardiography, presence of vascular calcifications on previously performed imaging tests) to adjust the estimate yielded by the Risk Factor-weighted Clinical Likelihood model.[163]	I	C
In individuals with a *very low* (≤5%) pre-test likelihood of obstructive CAD, deferral of further diagnostic tests should be considered.[139,164]	IIa	B
In individuals with a *low* (>5%–15%) pre-test likelihood of obstructive CAD, CACS should be considered to reclassify subjects and to identify more individuals with very low (≤5%) CACS-weighted clinical likelihood.[139,143,165]	IIa	B
In individuals with an initially low (>5%–15%) likelihood of obstructive CAD, exercise ECG and detection of atherosclerotic disease in non-coronary arteries may be considered to adjust the pre-test likelihood estimate.[144,166]	IIb	C

Algorithmus



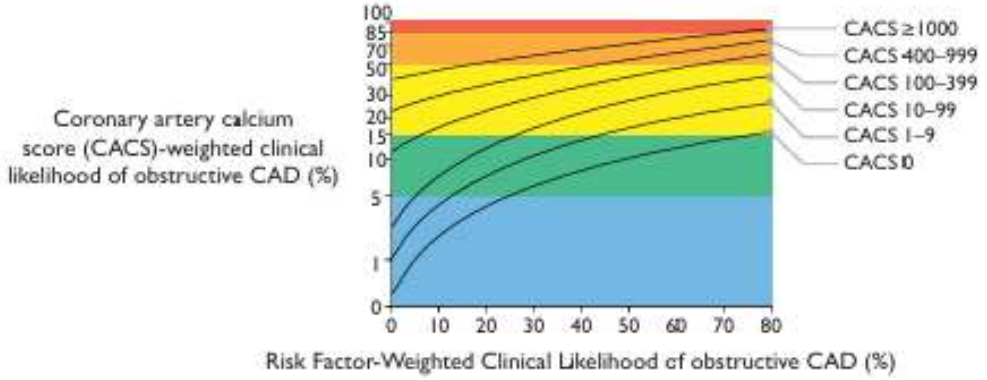
Abklärungsalgorithmus



Adaptiert von ESC-Guidelines CCS 2019

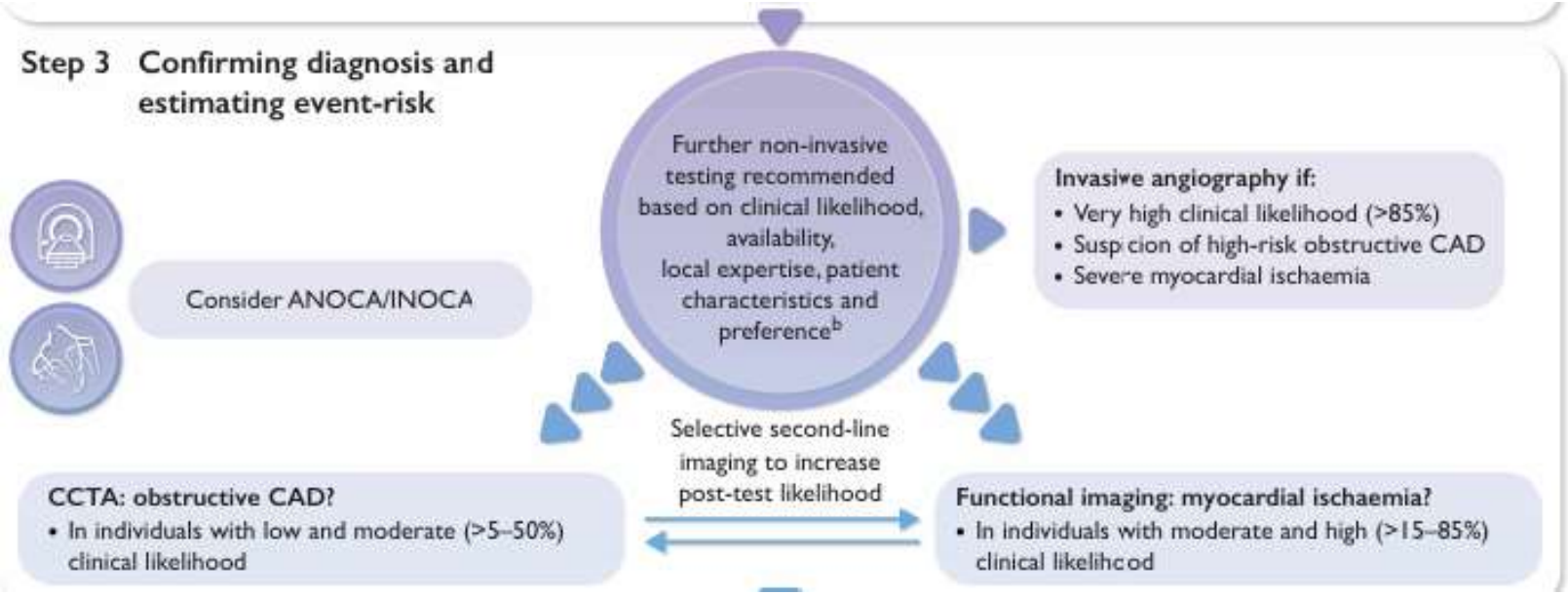
In individuals with a *low* (>5%–15%) pre-test likelihood of obstructive CAD, CACS should be considered to reclassify subjects and to identify more individuals with very low (≤5%) CACS-weighted clinical likelihood.[139,143,165]	**IIa**

3 **Consider reclassification of low RF-CL (>5–15%) using CACS to identify very low (≤5%) CACS-CL** **(Class IIa)**



ESC-Guidelines CCS 2024

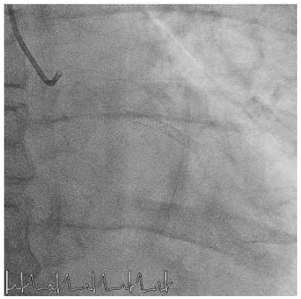
Algorithmus



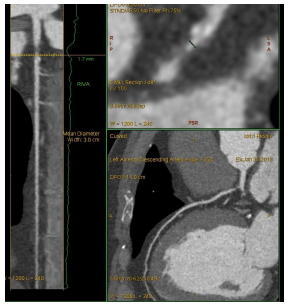
Wahl des passenden Tests

- **Keiner**
- **Belastungs-EKG**
- **Anatomisch nicht-invasiv**
  - Koronar-CT
- **Funktionell nicht-invasiv**
  - Stress-MRI
  - Stress-Echo
  - Myokardperfusions-SPECT
  - Myokardperfusions-PET
- **Koronarangiographie**

Ergometrie

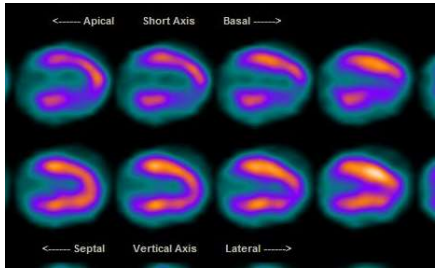


Koro

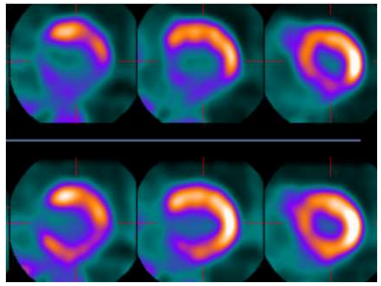


Koro-CT

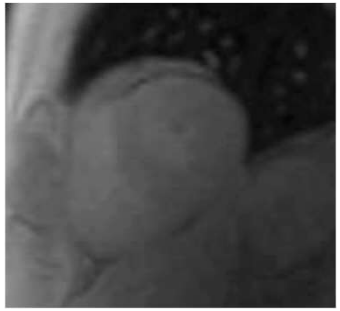
???



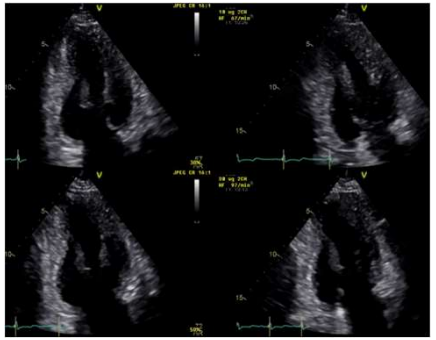
SPECT



PET



Stress-MRI

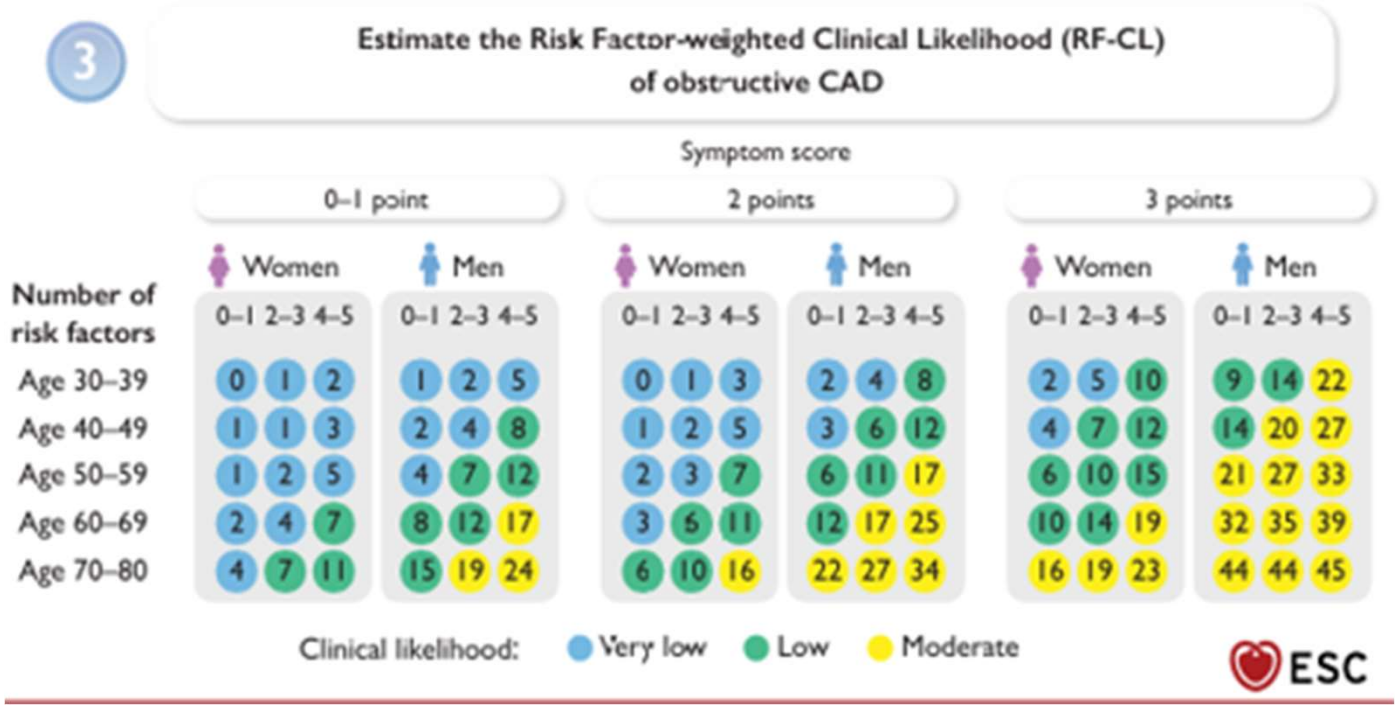


Stressecho

Wahl des passenden Testes

- **Keiner!**
- **Ergometrie**
- **Anatomisch nicht-invasiv**
  - Koronar-CT
- **Funktionell nicht-invasiv**
  - Stress-MRI
  - Stress-Echo
  - Myokardperfusions-SPECT
  - Myokardperfusions-PET
- **Koronarangiographie**
  - ± FFR

Wahl des passenden Testes



ESC-Guidelines CCS 2024

Wahl des passenden Testes

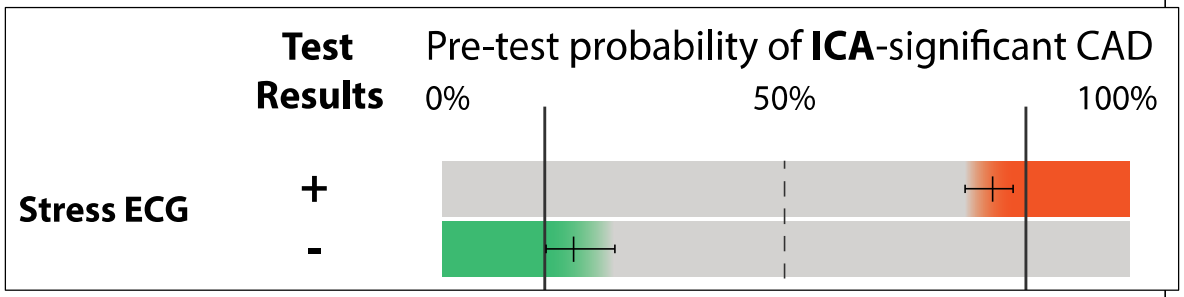
- **Keiner**
- **Ergometrie**
- **Anatomisch nicht-invasiv**
  - Koronar-CT
- **Funktionell nicht-invasiv**
  - Stress-MRI
  - Stress-Echo
  - Myokardperfusions-SPECT
  - Myokardperfusions-PET
- **Koronarangiographie**
  - ± FFR

Ergometrie

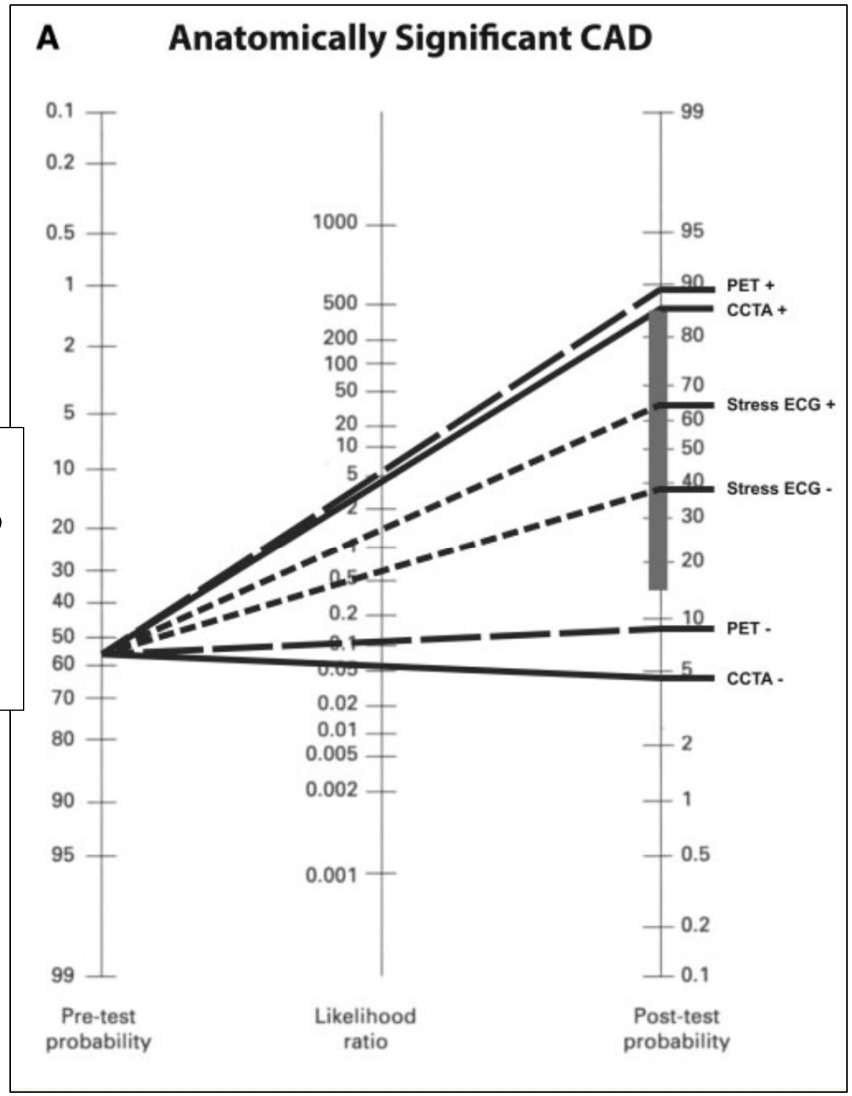
- Vorteile:
  - Verfügbarkeit
  - Kosten
  - Aussage über Leistungsfähigkeit

- Nachteile:
  - Tiefe Sensitivität und Spezifität
  - Keine Lokalisation der Ischämie möglich
  - Oft nicht genügend aussagekräftig (vorbestehende EKG-Veränderungen, mangelnde Leistungsfähigkeit)

Ergometrie

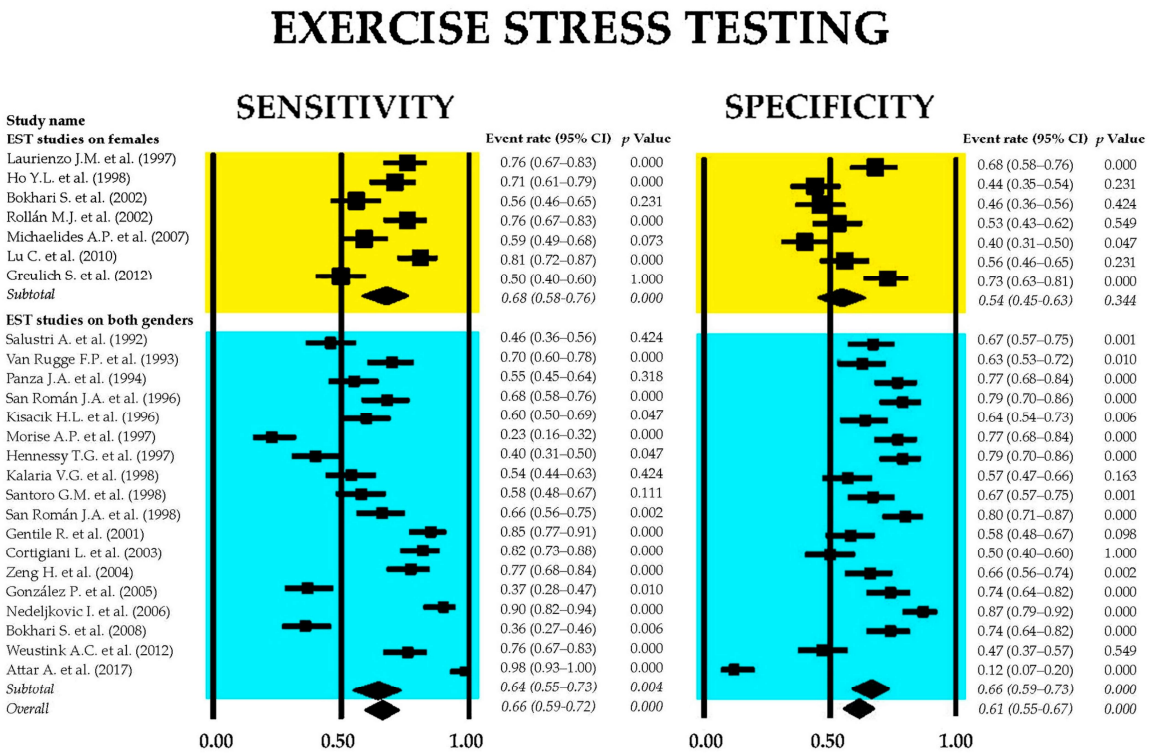


Knuuti Eur Heart J 2018



Juarez-Orozco Eur Heart J CV Imaging 2019

Ergometrie



Andrea Sonaglioni et al., *J. Clin. Med.* **2025**, *14*(17), 6238

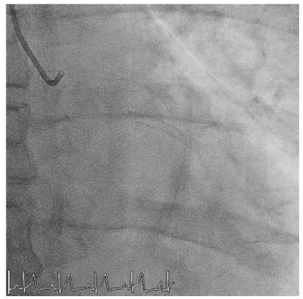
Belastungs-EKG

2013	Class[a]
Exercise ECG is recommendedas the initial test to establish a diagnosis of stable CAD in patients withsymptoms of angina and intermediate PTP of CAD (15–65%), free of anti-ischaemic drugs, unless they cannot exercise or display ECG changes that make the ECG non-evaluable.	I

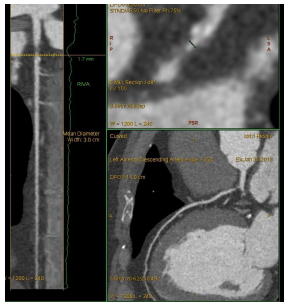
2019	Class[a]
Exercise ECG is recommended for the assessment of exercise tolerance, symptoms, arrhythmias, BP response, and event risk in selected patients.	I
Exercise ECG may be considered as an alternative test to rule-in or rule-out CAD when other non-invasive or invasive imaging methods are not available.	IIb

Recommendations	Class[a]	Level[b]
Exercise ECG is recommended in selected patients[c] for the assessment of exercise tolerance, symptoms, arrhythmias, BP response, and event risk.	I	C
Exercise ECG may be considered as an alternative test to rule in and rule out CAD when non-invasive imaging tests are unavailable.[148,166,188,190,191]	IIb	B
An exercise ECG may be considered to refine risk stratification and treatment.[188]	IIb	B
In individuals with a low (>5%–15%) pre-test likelihood of obstructive CAD, an exercise ECG may be considered to identify patients in whom further testing can be deferred.[144]	IIb	C

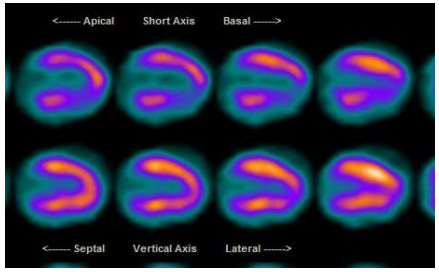
Ergometrie



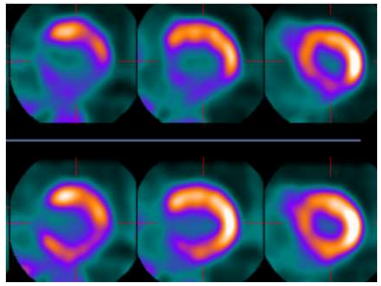
Koro



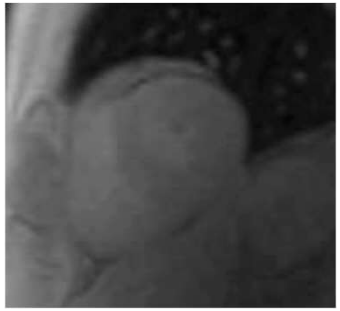
Koro-CT



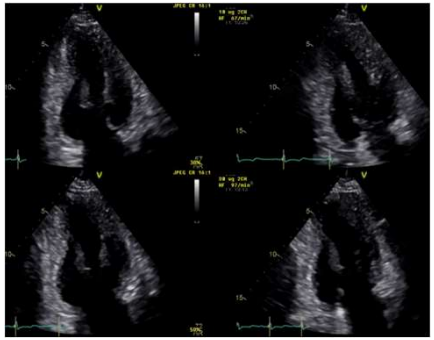
SPECT



PET



Stress-MRI



Stressecho

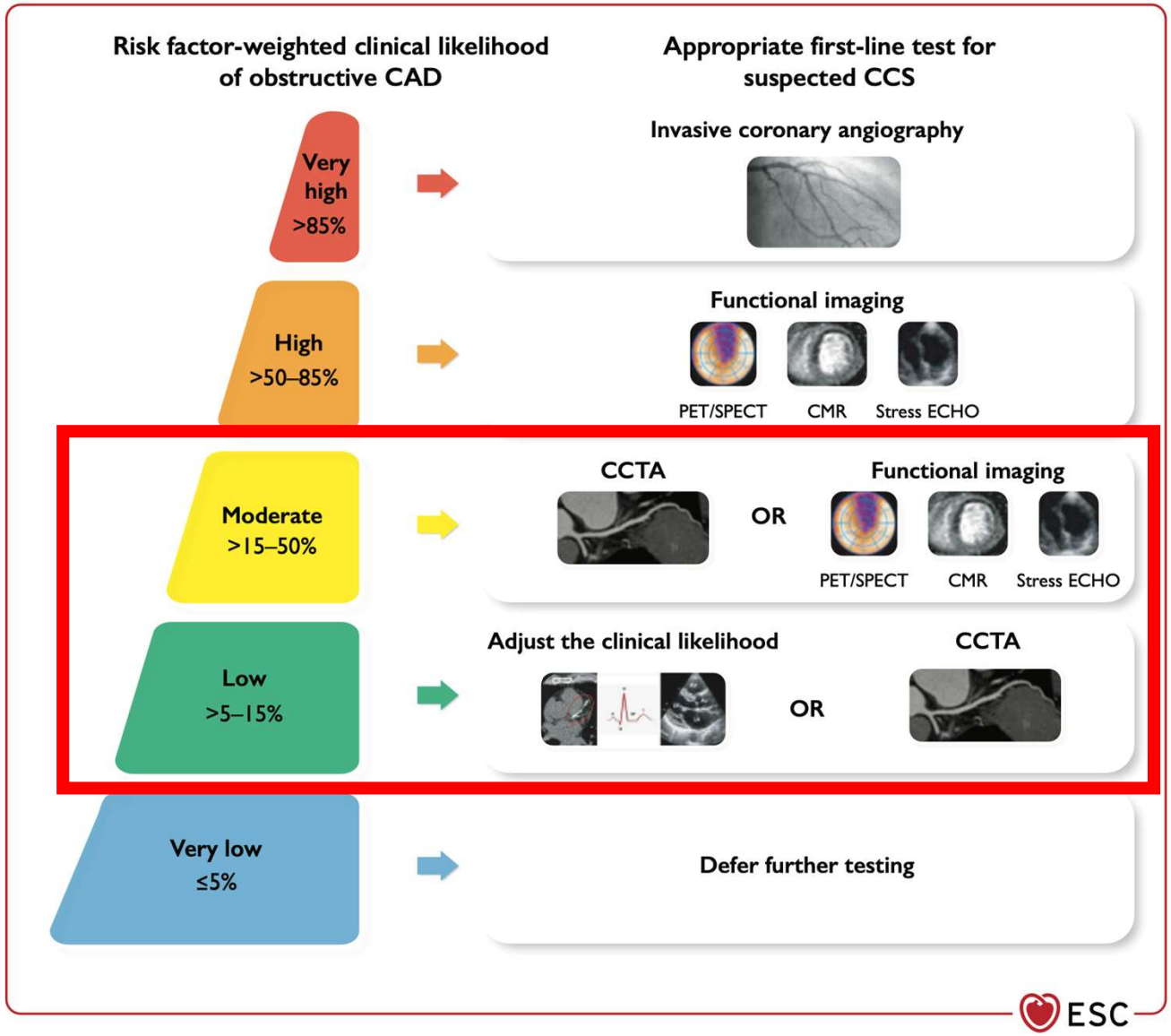
Wahl des passenden Testes

- **Keiner**
- **Belastungs-EKG**
- **Anatomisch nicht-invasiv**
  - Koronar-CT
- **Funktionell nicht-invasiv**
  - Stress-MRI
  - Stress-Echo
  - Myokardperfusions-SPECT
  - Myokardperfusions-PET
- **Koronarangiographie**
  - ± FFR

Koronar-CT

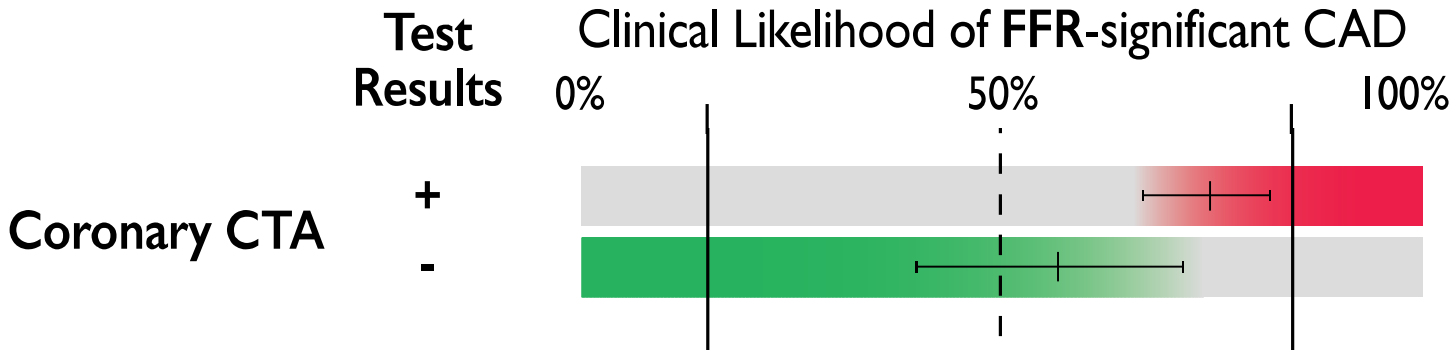
Bevorzugter Test wenn

- klinische Wahrscheinlichkeit für KHK im tieferen Bereich
- Keine KHK bekannt
- Hohe Wahrscheinlichkeit für gute Bildqualität


Risk factor-weighted clinical likelihood of obstructive CAD
Appropriate first-line test for suspected CCS
Very high >85%
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
ESC

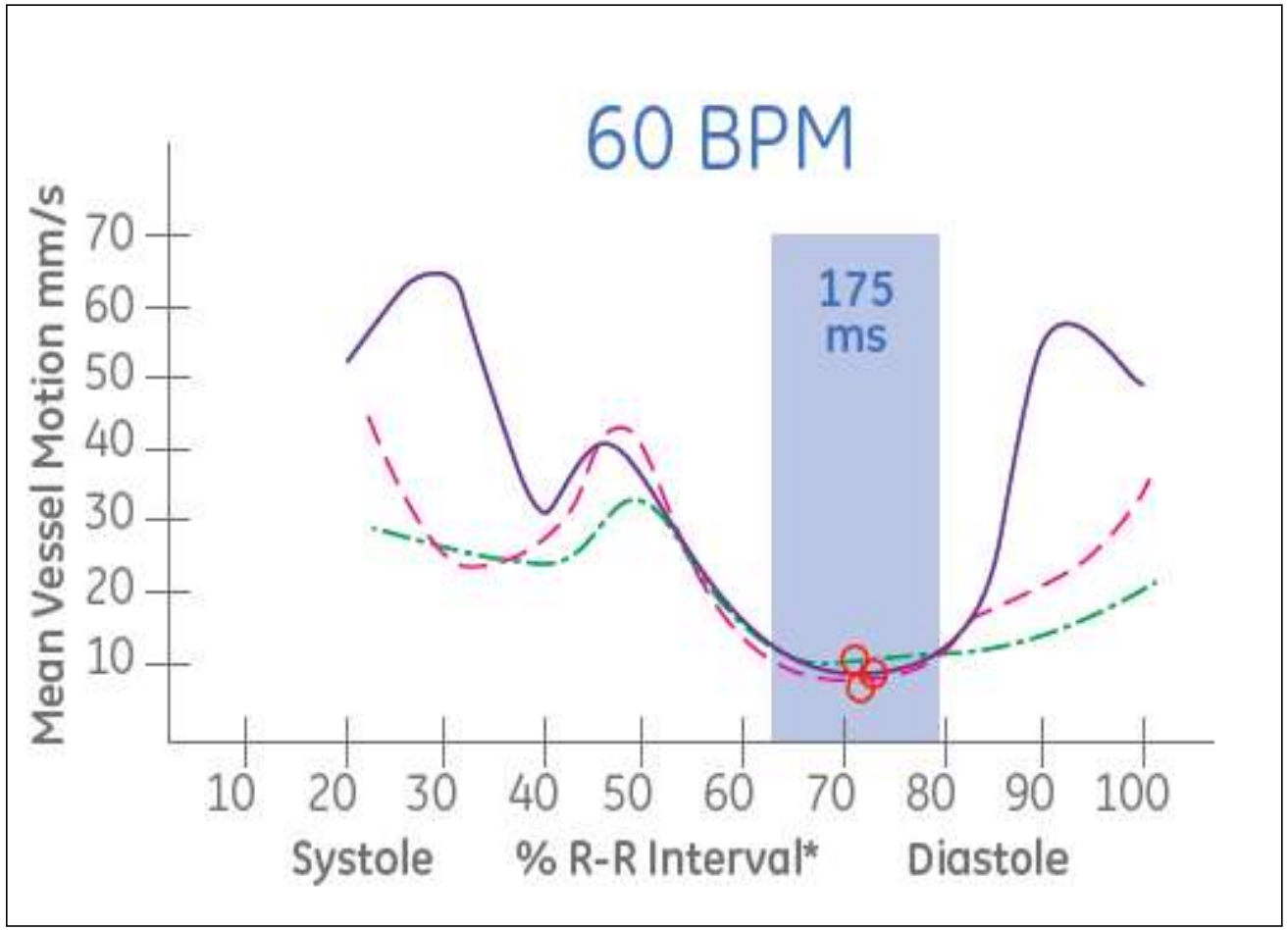
Koronar-CT

- Gemäss ESC-Guidelines bei RF-CL 5-50% empfohlen
- Sehr gut, um KHK auszuschliessen
- Sehr schnell durchgeführte Untersuchung, tiefe Strahlendosis (1-1.5mSv)



Knuuti Eur Heart J 2018

Koronar-CT

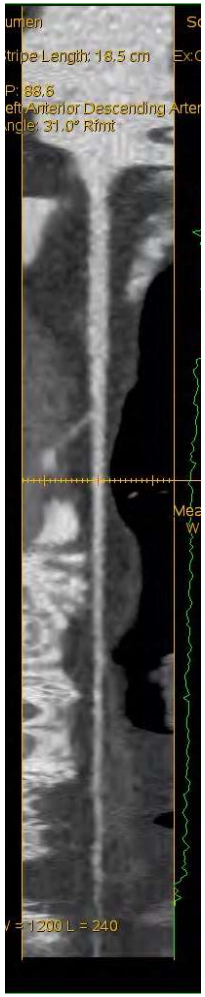


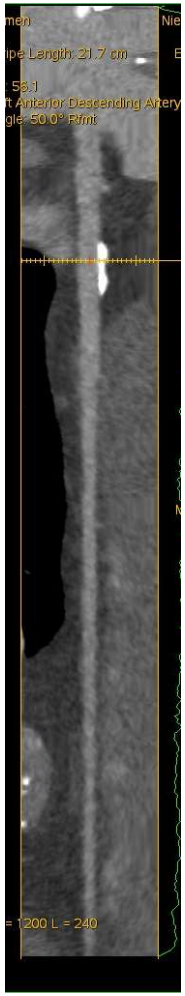
Husmann Radiology 2007

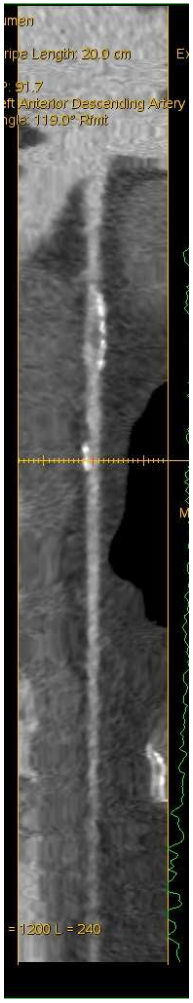
Koronar-CT - Voraussetzungen

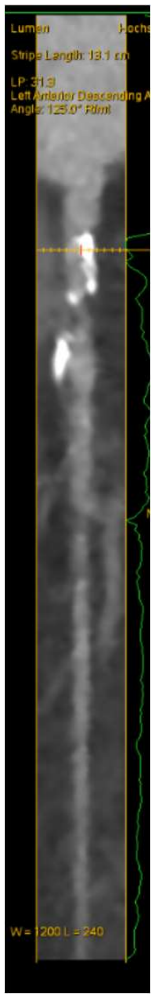
- Regelmässiger, relativ langsamer Puls (Ziel <65/min), Vorbereitung mit Ivabradin/Betablocker (peroral/intravenös)
- (Vorhofflimmern relative Kontraindikation)
- Mind. 64-Zeiler-CT für gute Auflösung
- Patient muss Atem anhalten können
- Erschwerte Beurteilbarkeit bei viel vorhandenem Kalk, Artefakt durch Stents

Koronar-CT


Stripe Length: 18.5 cm
Left Anterior Descending Arter
Angle: 31.0° Rimt
W = 1200 L = 240


Stripe Length: 21.7 cm
Left Anterior Descending Artery
Angle: 50.0° Rimt
= 1200 L = 240

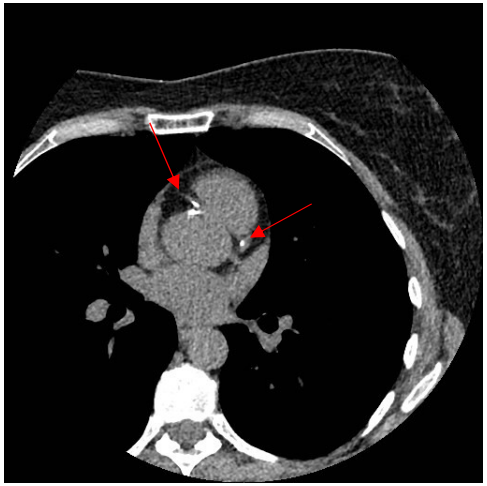
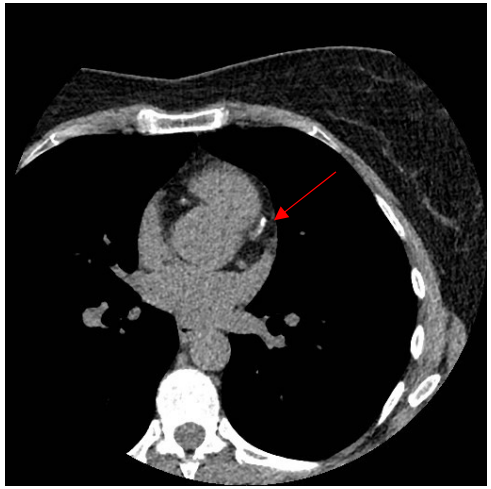
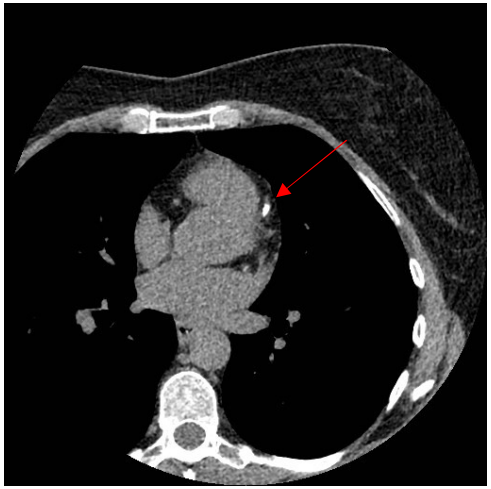
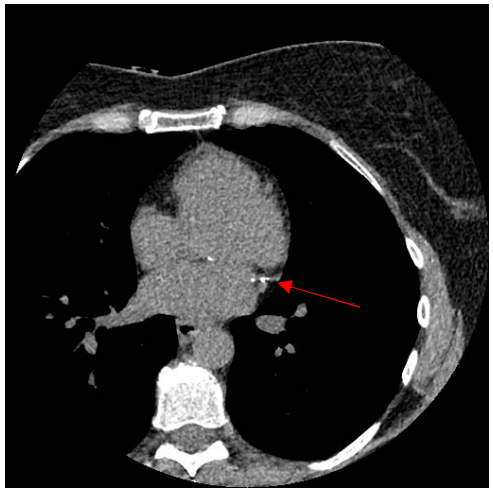
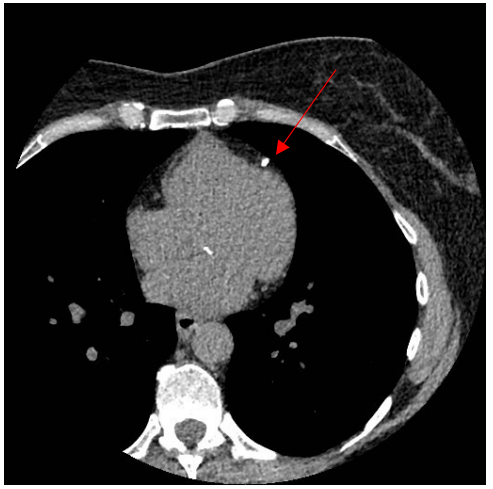

Stripe Length: 20.0 cm
Left Anterior Descending Artery
Angle: 119.0° Rimt
= 1200 L = 240


Lumen
Stripe Length: 13.1 cm
Left Anterior Descending A
Angle: 125.0° Rimt
W = 1200 L = 240

Koronar-CT – Calciumscoring

- Geringe Strahlenbelastung, Nativ-CT
- Messung der Plaques (>130 Hounsfield Units) mit Hilfe einer Software → Agatston Score
- Hoher negativer prädiktiver Wert (96-100%) für stenosierende KHK bei Calcium Score 0

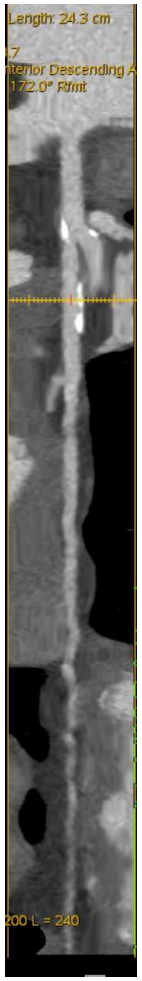
Calcium Score

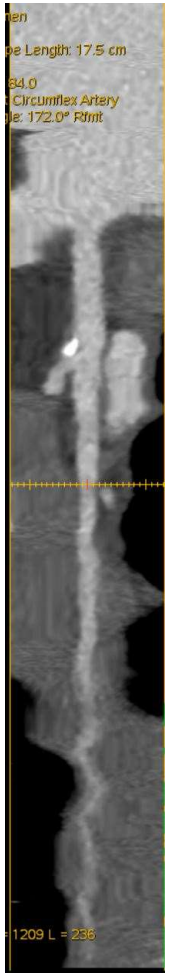
CACS 383

Calcium Score

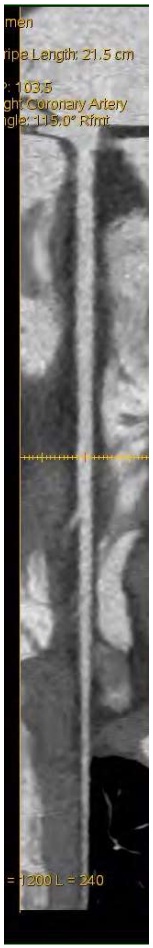
RIVA



RCX

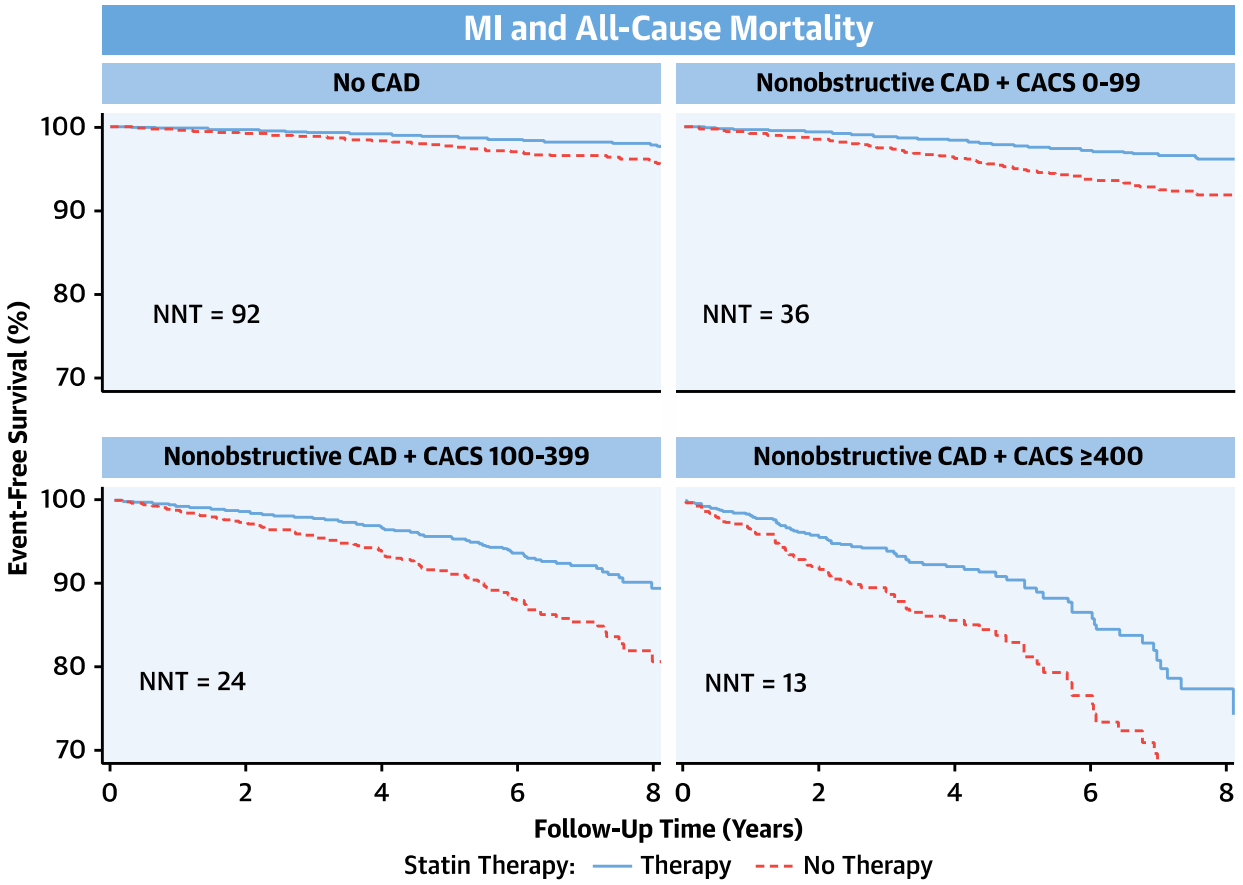


RCA



CACS 389

CENTRAL ILLUSTRATION **Adjusted Event Free Survival Curves as a Function of Statin Therapy and Coronary Artery Disease Burden**



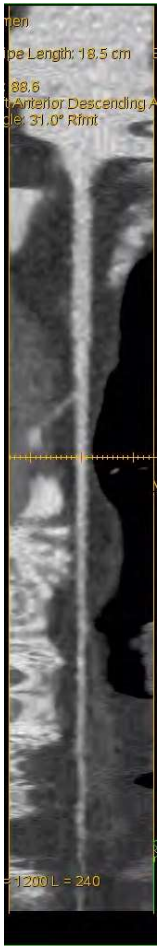
Øvrehus, K.A. et al. J Am Coll Cardiol Img. 2021;14(12):2400-2410.

Ovrehus JACC CV Imaging 2021

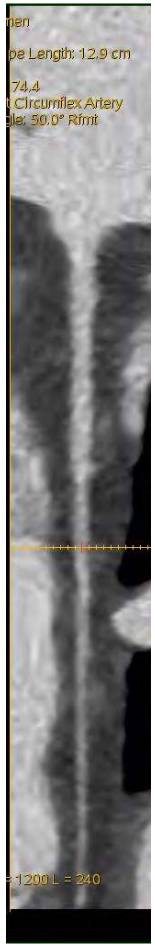
Event-free survival according to CAD burden and statin therapy during follow-up adjusted for age, sex, hypertension, diabetes, family history of premature CAD, tobacco, comorbidity, and aspirin use. CACS = coronary artery calcium score; CAD = coronary artery disease; MI = myocardial infarction; NNT = number needed to treat with statins for 5 years to prevent MI or all-cause mortality.

Koronar-CT – Power of Zero

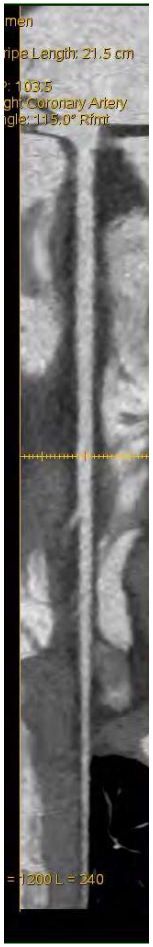
RIVA



RCX

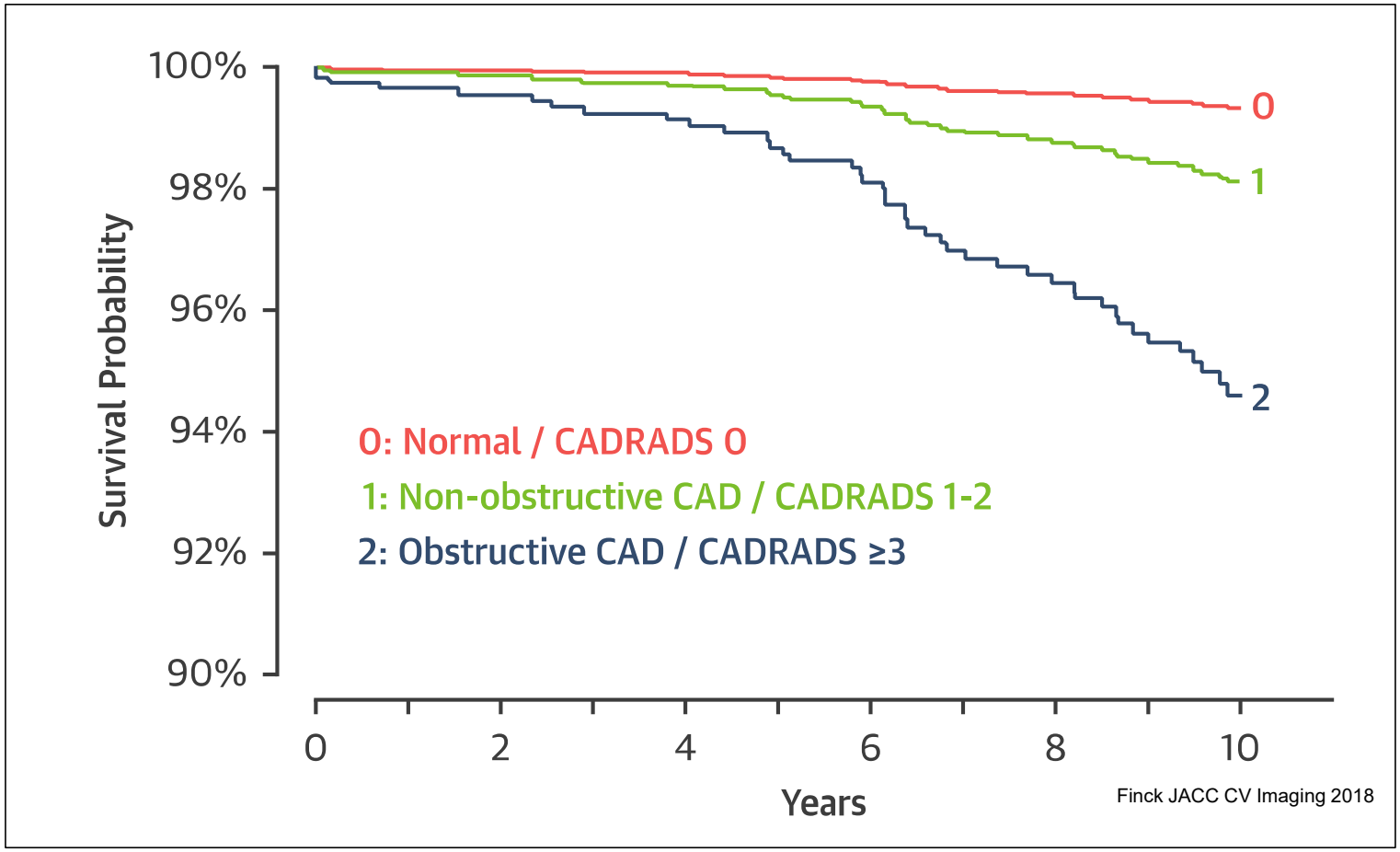


RCA



CACS 0

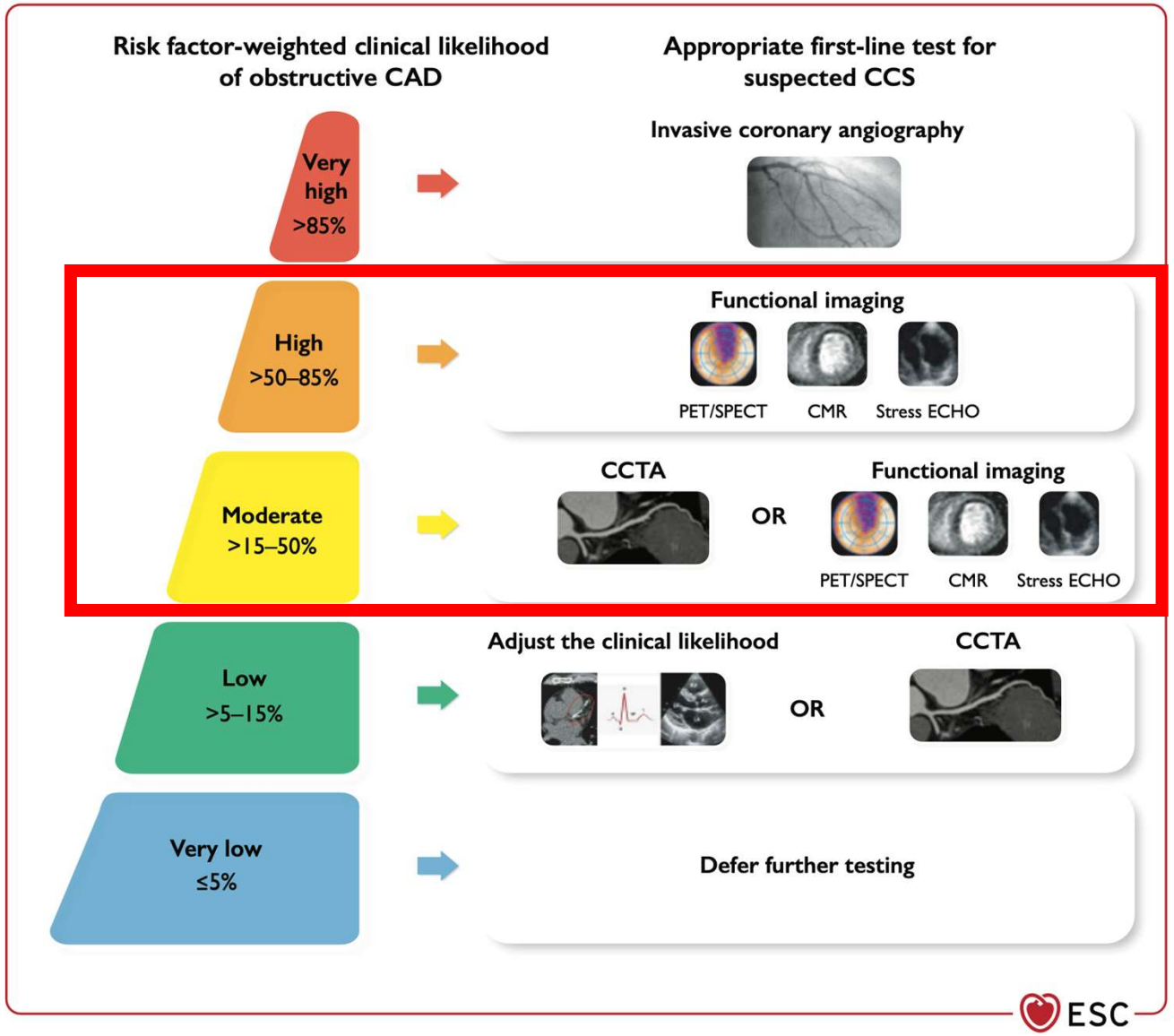
Calcium Score - Power of Zero



Recommendations	Class[a]	Level[b]
In individuals with suspected CCS and low or moderate (>5%–50%) pre-test likelihood of obstructive CAD, CCTA is recommended to diagnose obstructive CAD and to estimate the risk of MACE.[33,34,145,212,214–221]	I	A
CCTA is recommended in individuals with low or moderate (>5%–50%) pre-test likelihood of obstructive CAD to refine diagnosis if another non-invasive test is non-diagnostic.[222]	I	B
CCTA is not recommended in patients with severe renal failure (eGFR <30 mL/min/1.73 m^2), decompensated heart failure, extensive coronary calcification, fast irregular heart rate, severe obesity, inability to cooperate with breath-hold commands, or any other conditions that can make obtaining good imaging quality unlikely.	III	C

Wahl des passenden Testes

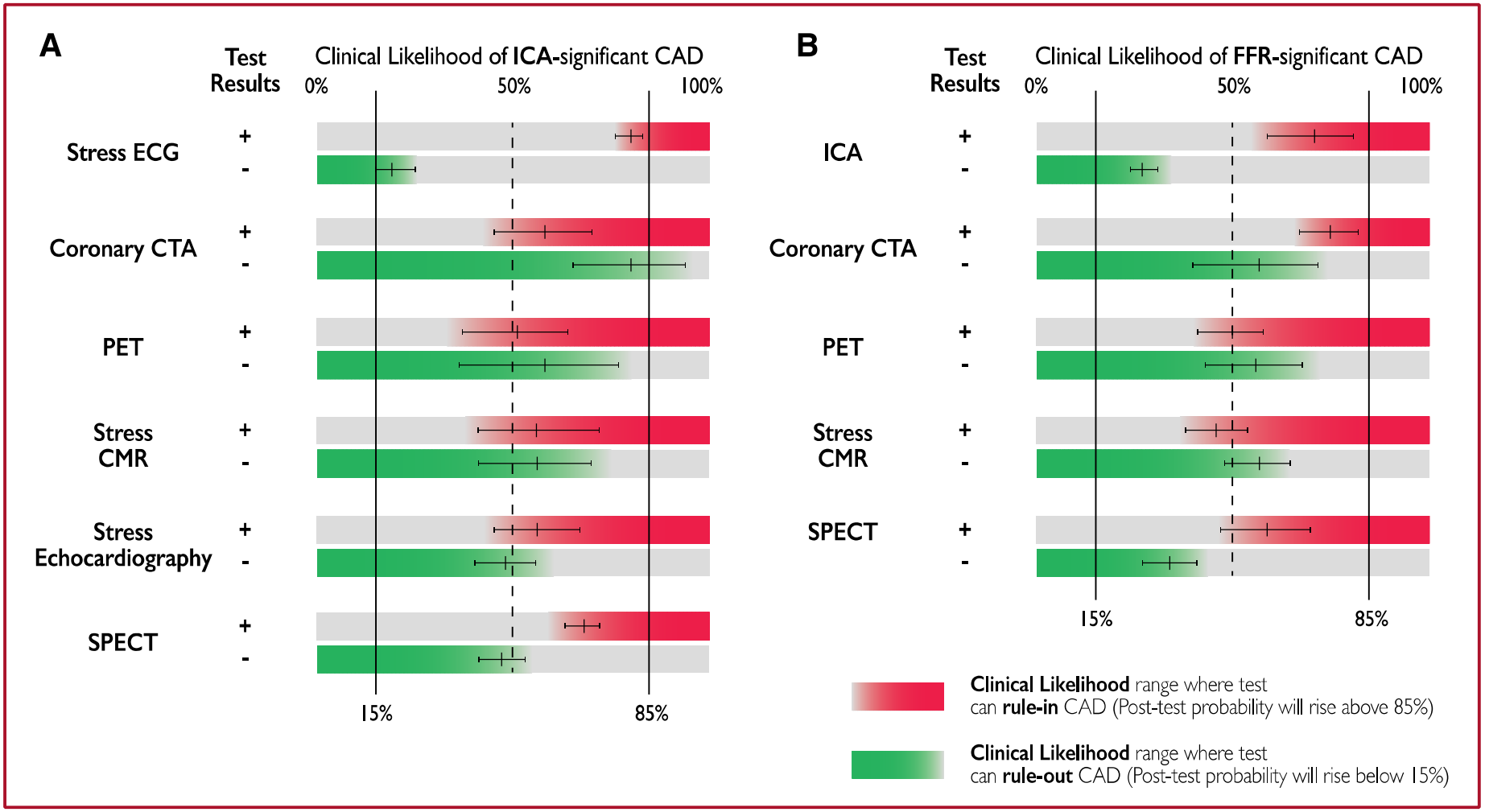
- **Keiner**
- **Belastungs-EKG**
- **Anatomisch nicht-invasiv**
  - Koronar-CT
- **Funktionell nicht-invasiv**
  - Stress-Echo
  - Stress-MRI
  - Myokardperfusions-SPECT
  - Myokardperfusions-PET
- **Koronarangiographie**


Risk factor-weighted clinical likelihood of obstructive CAD
Appropriate first-line test for suspected CCS
Very high >85%
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
ESC

Nicht-invasive funktionelle Tests

- Können besser Patienten mit KHK korrekt erkennen als CCTA
- Bevorzugt bei Patienten mit höherer klinischer Wahrscheinlichkeit für eine KHK oder bei schon bekannter KHK
- Guidelines sagen nicht, welchen funktionellen Test man machen soll

Wahl des passenden Testes



Herz-MRI

Health.ucdavis.edu

Herz-MRI - Voraussetzungen

– Hämodynamisch stabiler, kooperativer Patient (muss während ca. 30 Min teils relativ lange Atemkommandos befolgen können)

– ± regelmässiger Herzrhythmus

Herz-MRI - Schwierigkeiten

- Klaustrophobie
- „anspruchsvolle“ Untersuchung
- Adipositas
- Potenzielle Schädigung ferromagnetischer Implantate
  - MR-kompatible Schrittmacher / ICD; cave alte/epikardiale Elektroden!
  - Herzklappen grundsätzlich MR-kompatibel
  - www.mrisafety.com

Medikamentöse Vasodilatation durch **Regadenoson** oder **Adenosin**

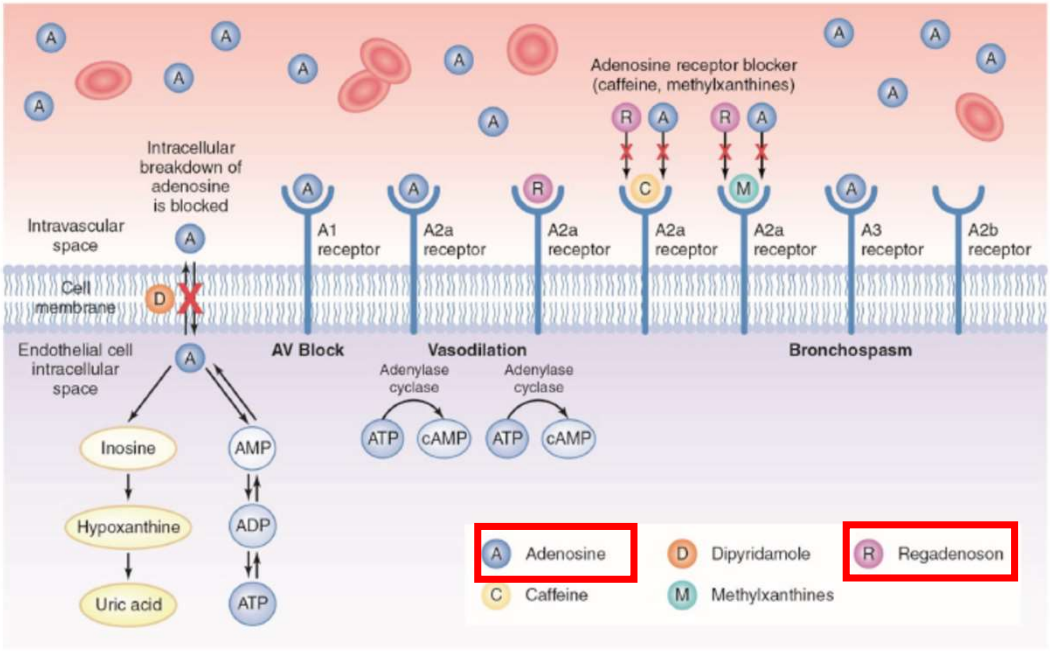


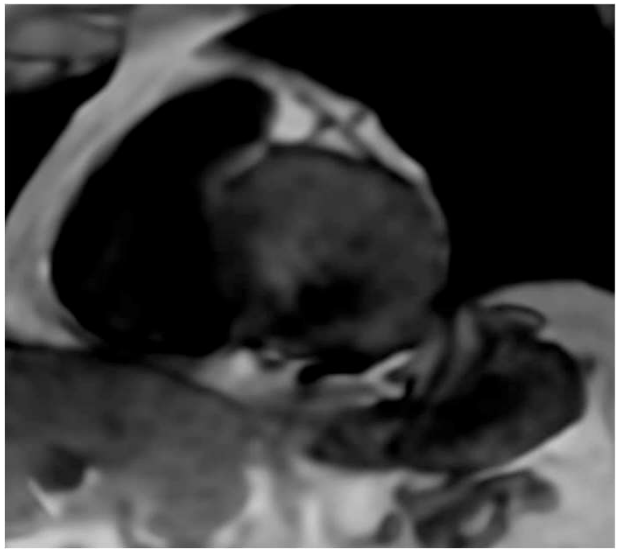
Figure 1. Mechanism of action of coronary vasodilators. *ADP*, Adenosine diphosphate; *AMP*, adenosine monophosphate; *ATP*, adenosine triphosphate; *AV*, atrioventricular; and *cAMP*, cyclic adenosine monophosphate.

EANM procedural guidelines for radionuclide myocardial perfusion imaging with SPECT and SPECT/CT: 2015 revision. Hein J. Verbene et al. Eur J Nucl Med Mol Imaging (2015) 42: 1929-1940.

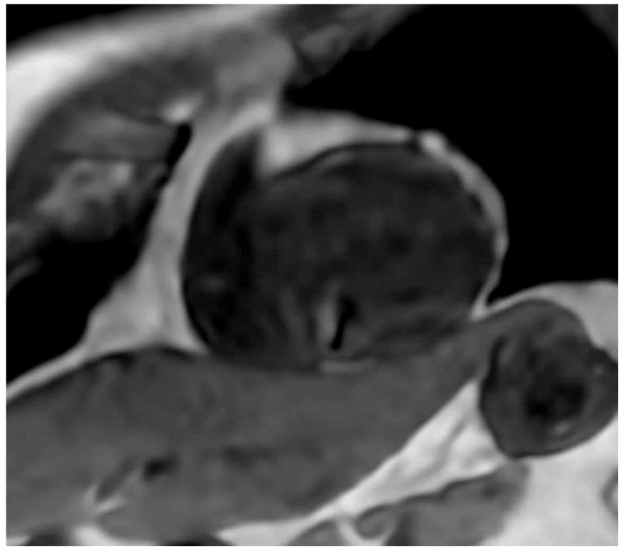
Stress-MRI

– während medikamentöser Belastung Injektion von Kontrastmittel → Scan während First-Pass des KM→ Beurteilung der Perfusion indem wir die Verteilung des KM im Myokard anschauen

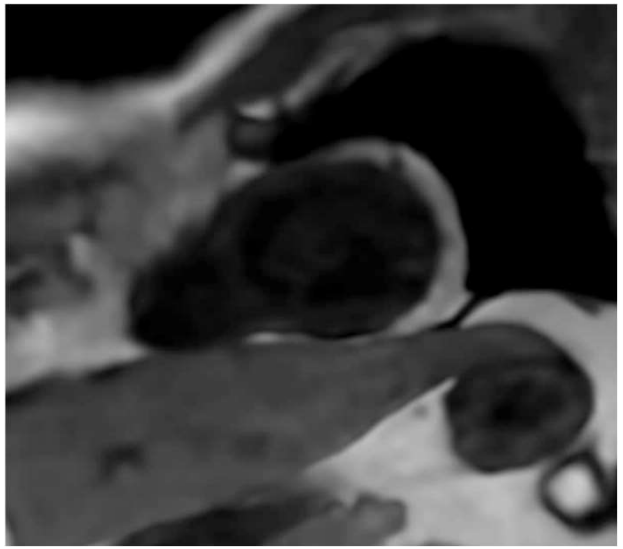
Stress-MRI Beispiel



basal

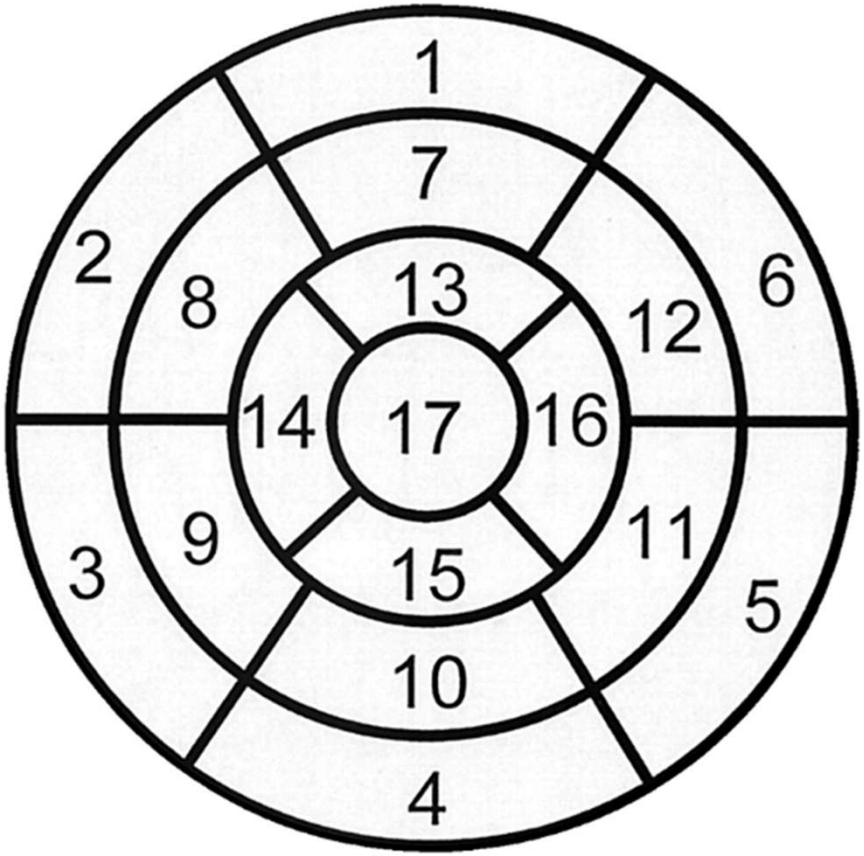


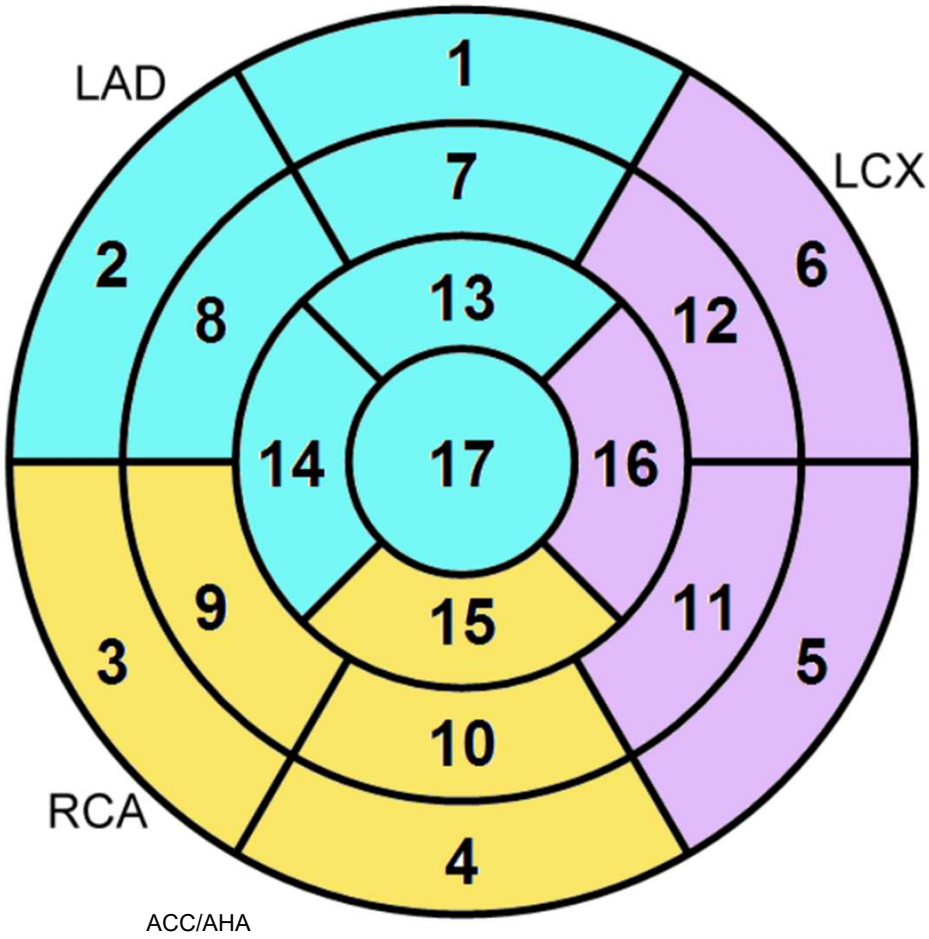
mid



apikal

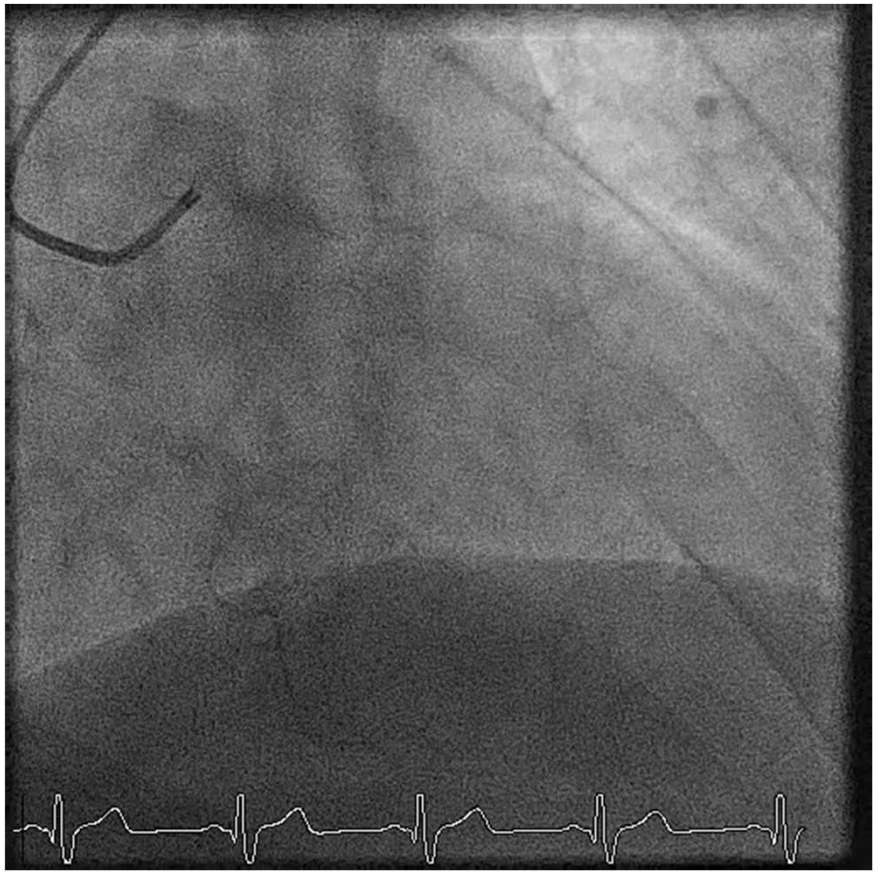
Stress-MRI – Beispiel

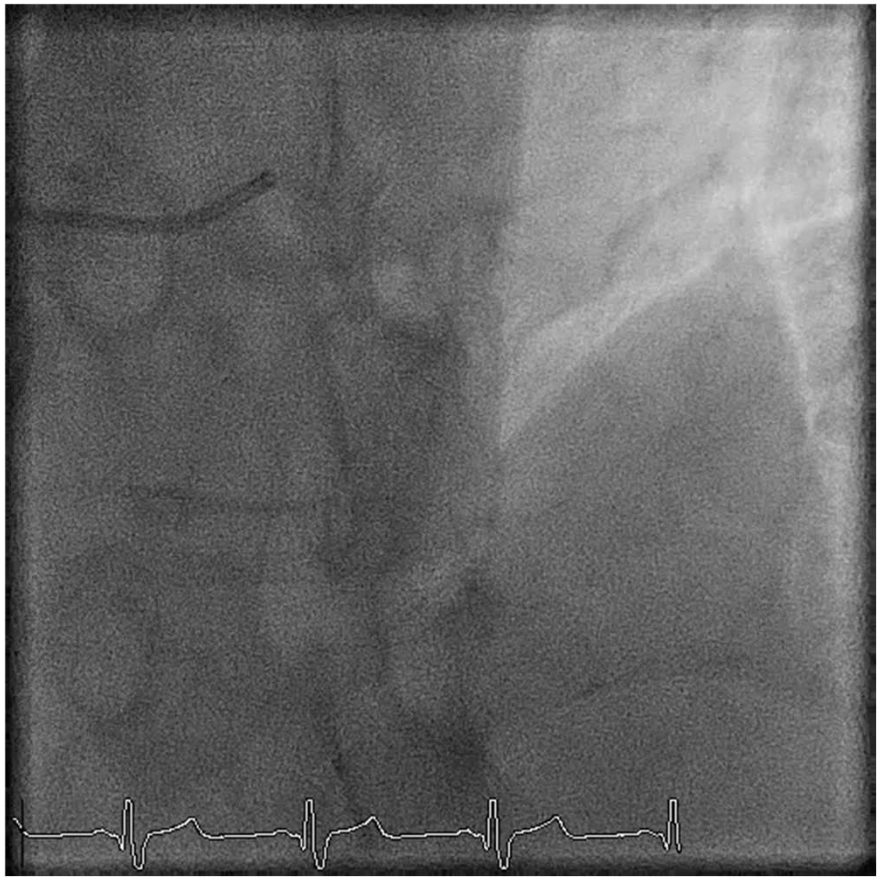




ACC/AHA

Stress-MRI – Beispiel

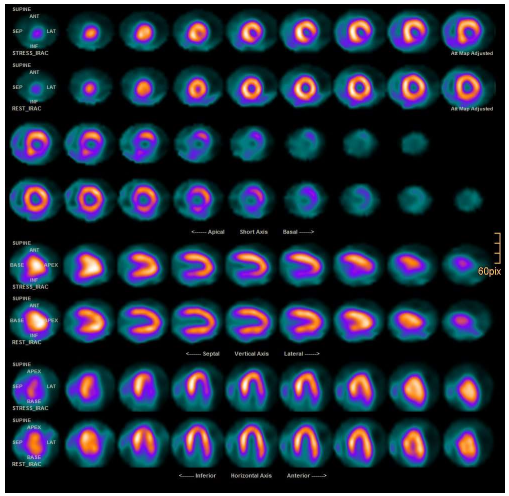




Myokardperfusions-SPECT

– SPECT: single photon emission computed tomography

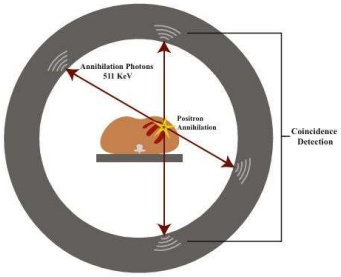
– Einsatz seit 1973 (^{201}Thallium), seit 1990 ist ^{99m}Technetium FDA-approved
→ Jahrzehntelang validierte Methode



Myokardperfusions-PET/CT

PET = Positron Emission Tomography

Fig. 1 PET technology principle. Diagram depicting principles of annihilation and coincidence detection



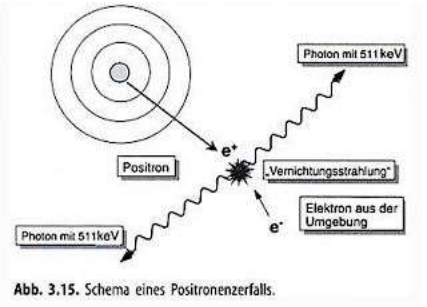


Abb. 3.15. Schema eines Positronenzerfalls.

– Injektion eines Radiotracers, welcher sich flussabhängig im Myokard anreichert

– Erlaubt zusätzlich die quantitative Beurteilung der Myokardperfusion durch Flussmessungen

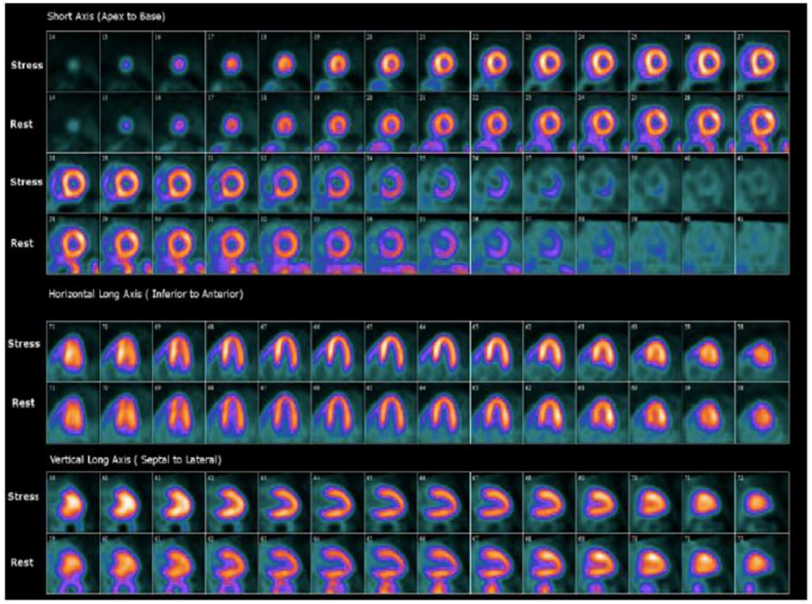
Myokardperfusions-PET/CT

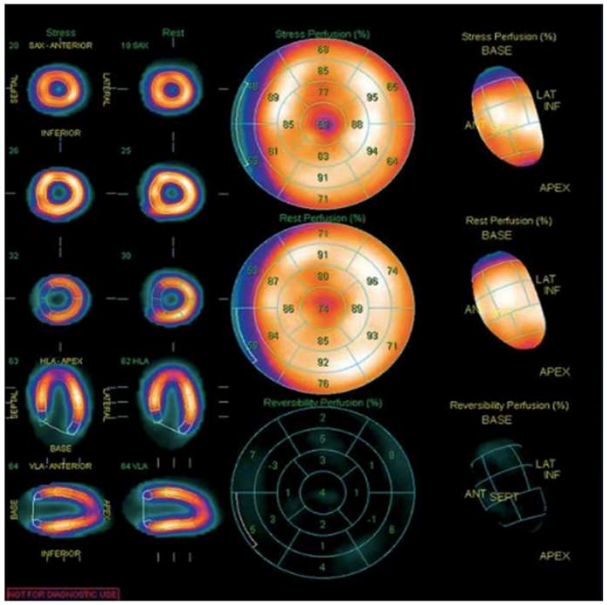
Myokardperfusions-PET/CT

Medikamentöse Belastung (direkt im Scanner) mit

– Regadenoson
– Adenosin
– (Dobutamin)

– Qualitative/semiquantitative Beurteilung: analog zum SPECT





– Quantitative Beurteilung: Bestimmung des koronaren Blutflusses in Ruhe und unter Belastung, somit Bestimmung der **koronaren Flussreserve**

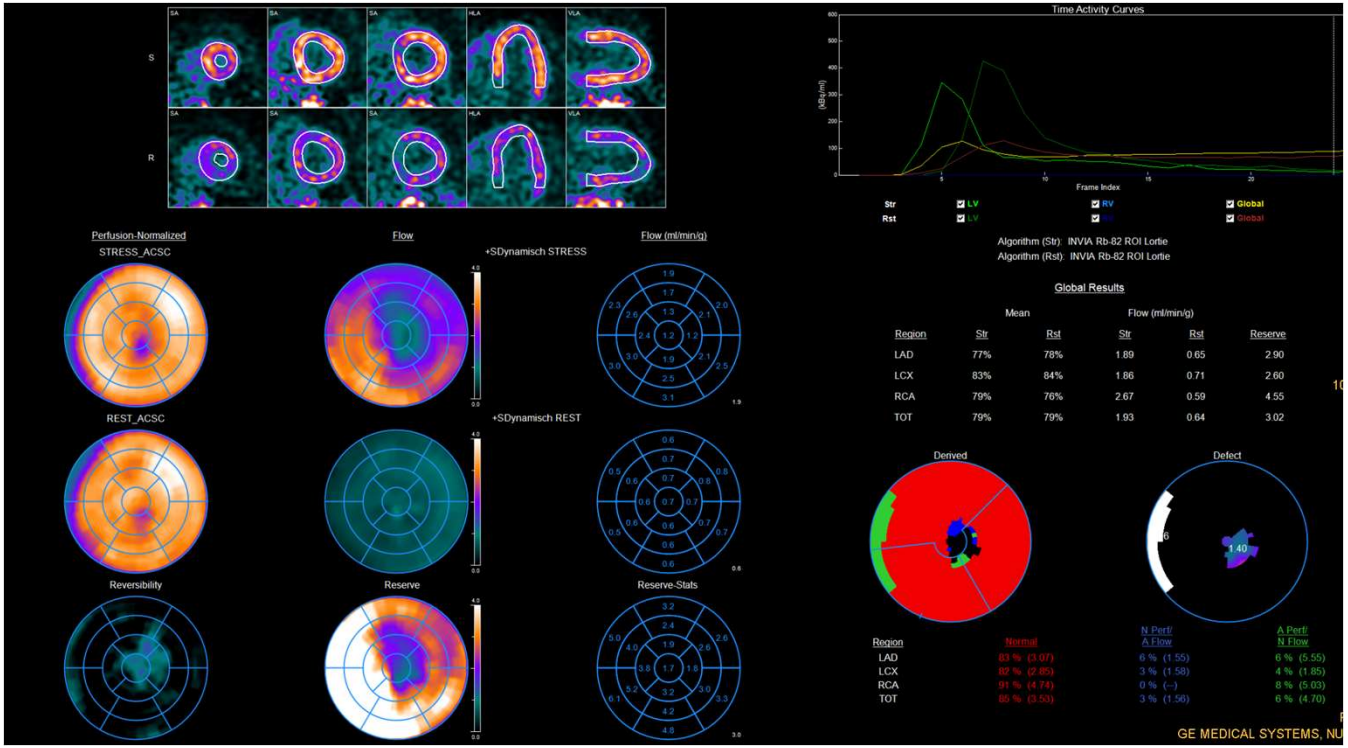


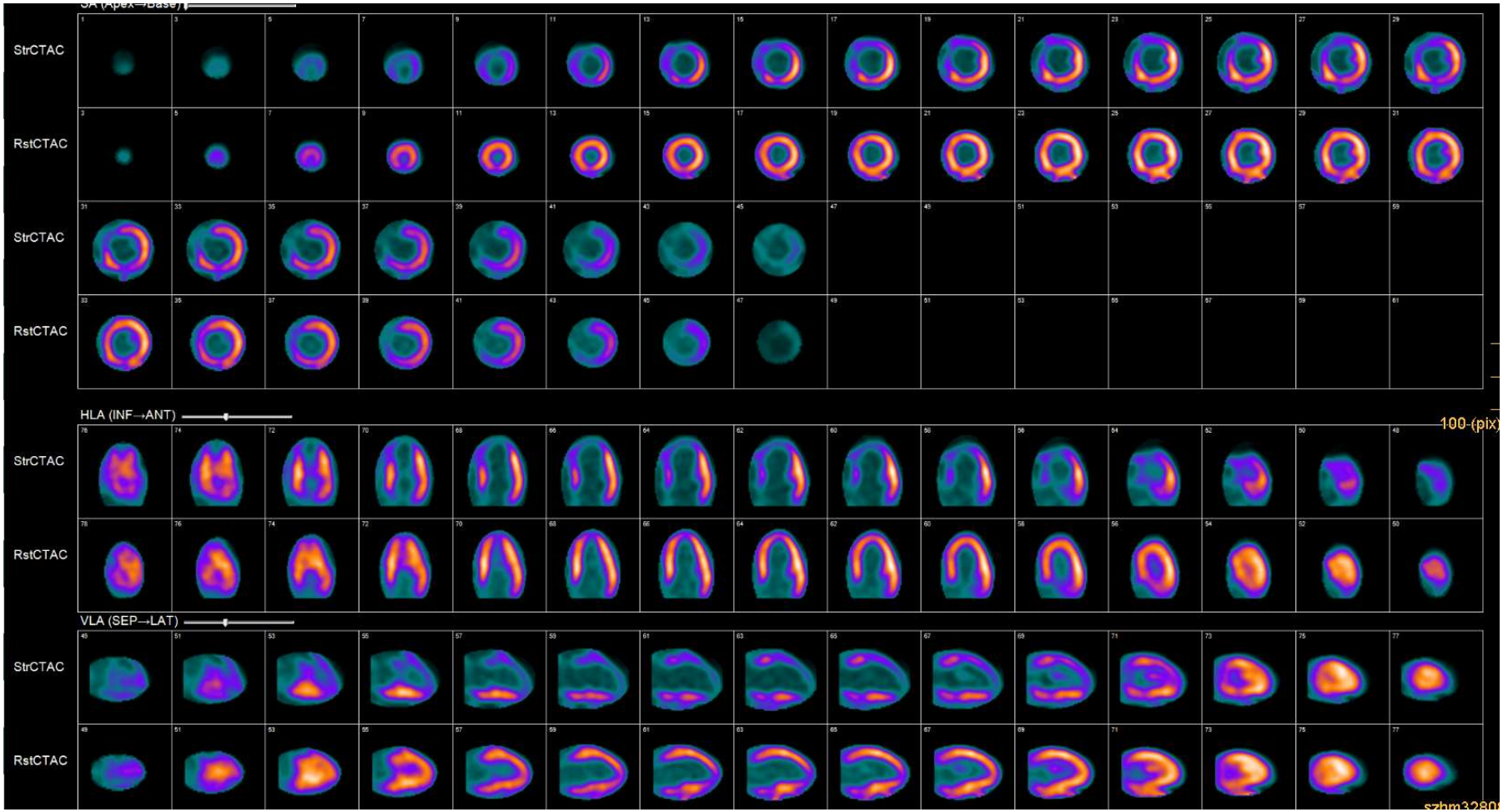
Table 1. General interpretation and classification of risk in relation to global MBFR.

MBFR	Interpretation	Relative risk
>2	Normal	Low
1.7-2	Mildly abnormal	Intermediate
1.2-<1.7	Abnormal	High
<1.2 with a perfusion defect	Highly abnormal	Very high
<1.2 without a perfusion defect	Consider non-diagnostic study	Indeterminate

Cutoffs are generally arbitrary and may vary slightly between labs, software used, stressors used, and published studies. The principle is that the lower the flow reserve the greater the relative risk

Bateman et al; Practical Guide for Interpreting and Reporting Cardiac PET Measurements of MBF, Journal of Nuclear Medicine, March 2021

Myokardperfusions-PET - Beispiel



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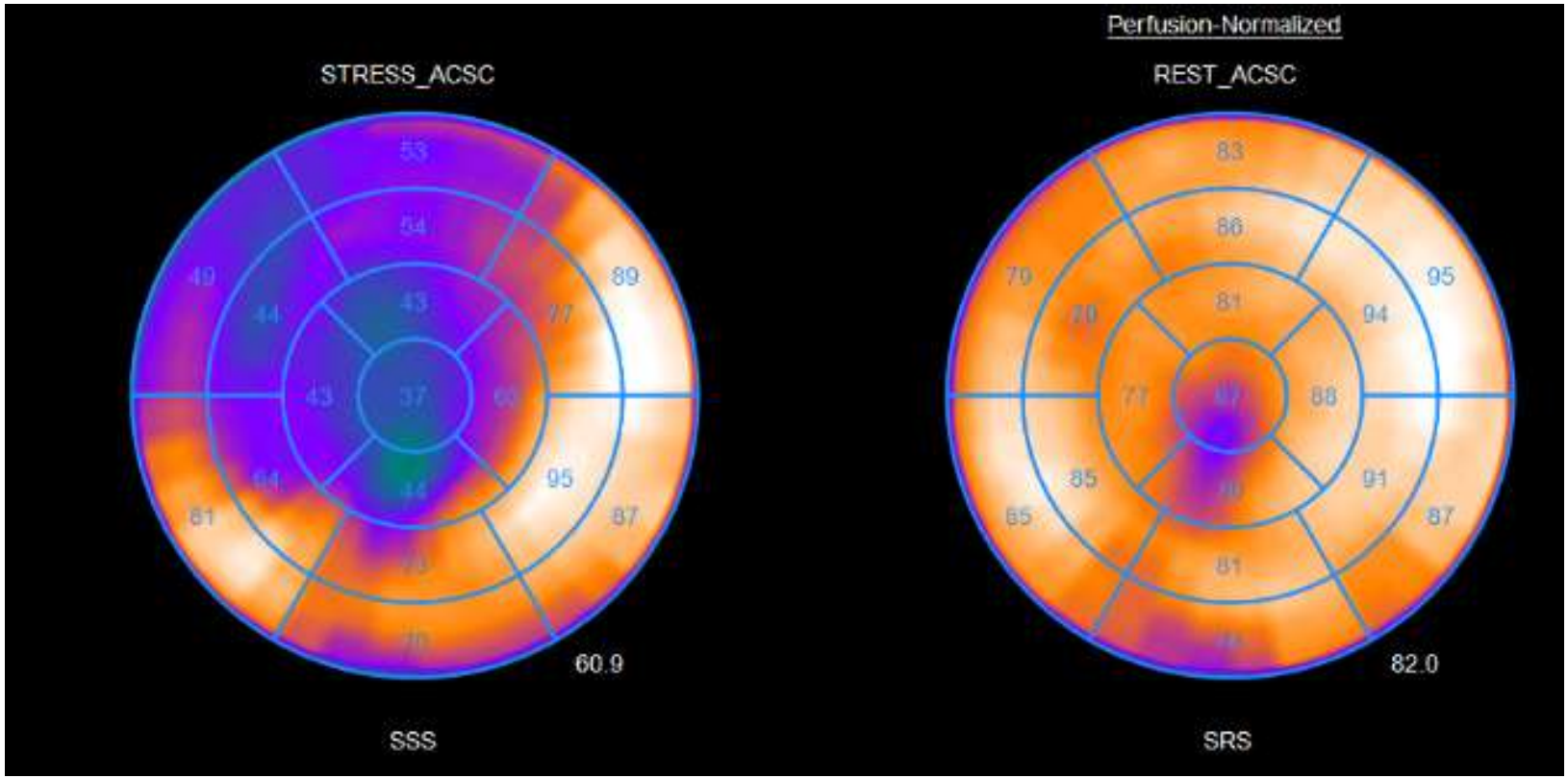

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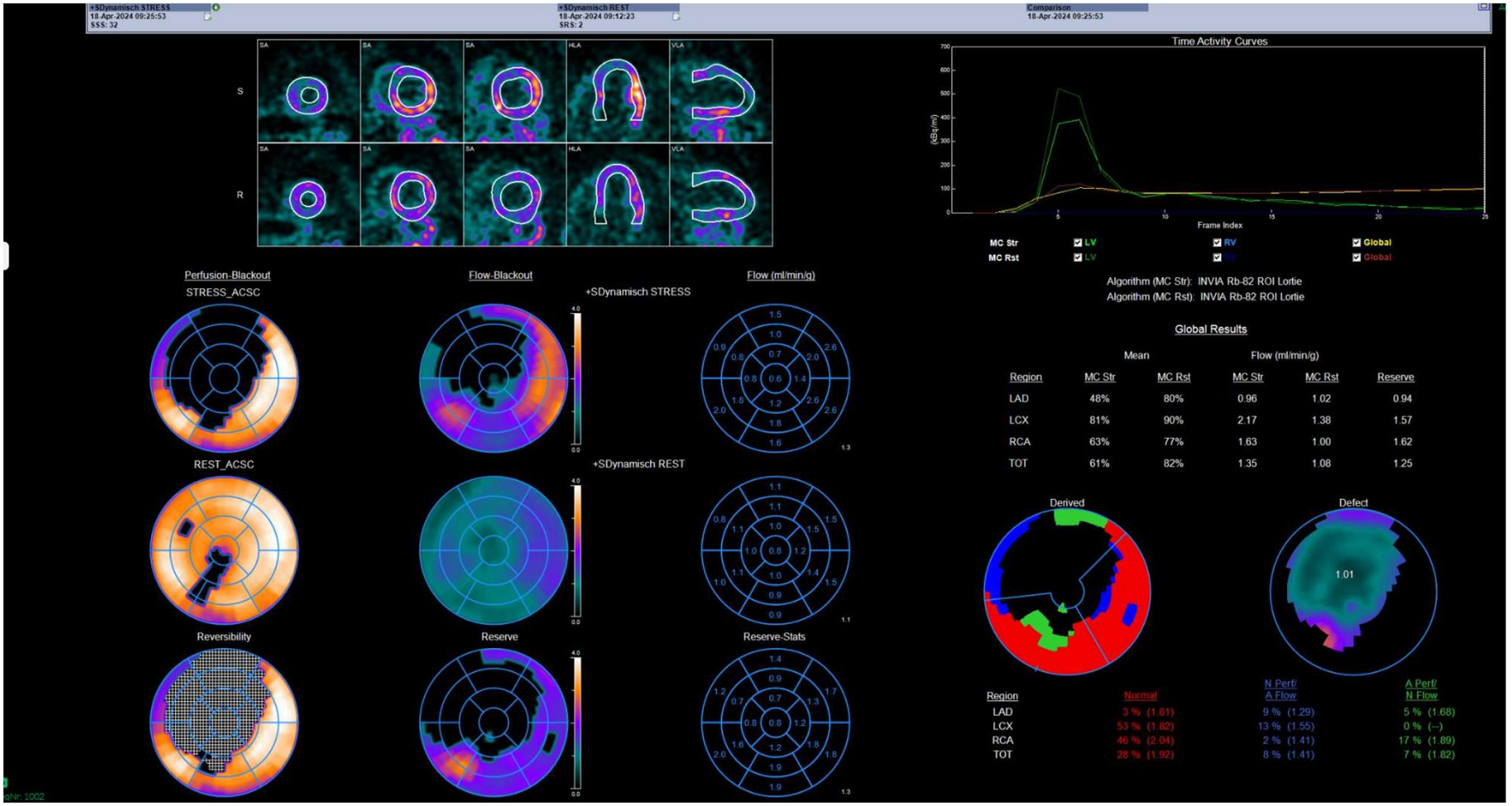
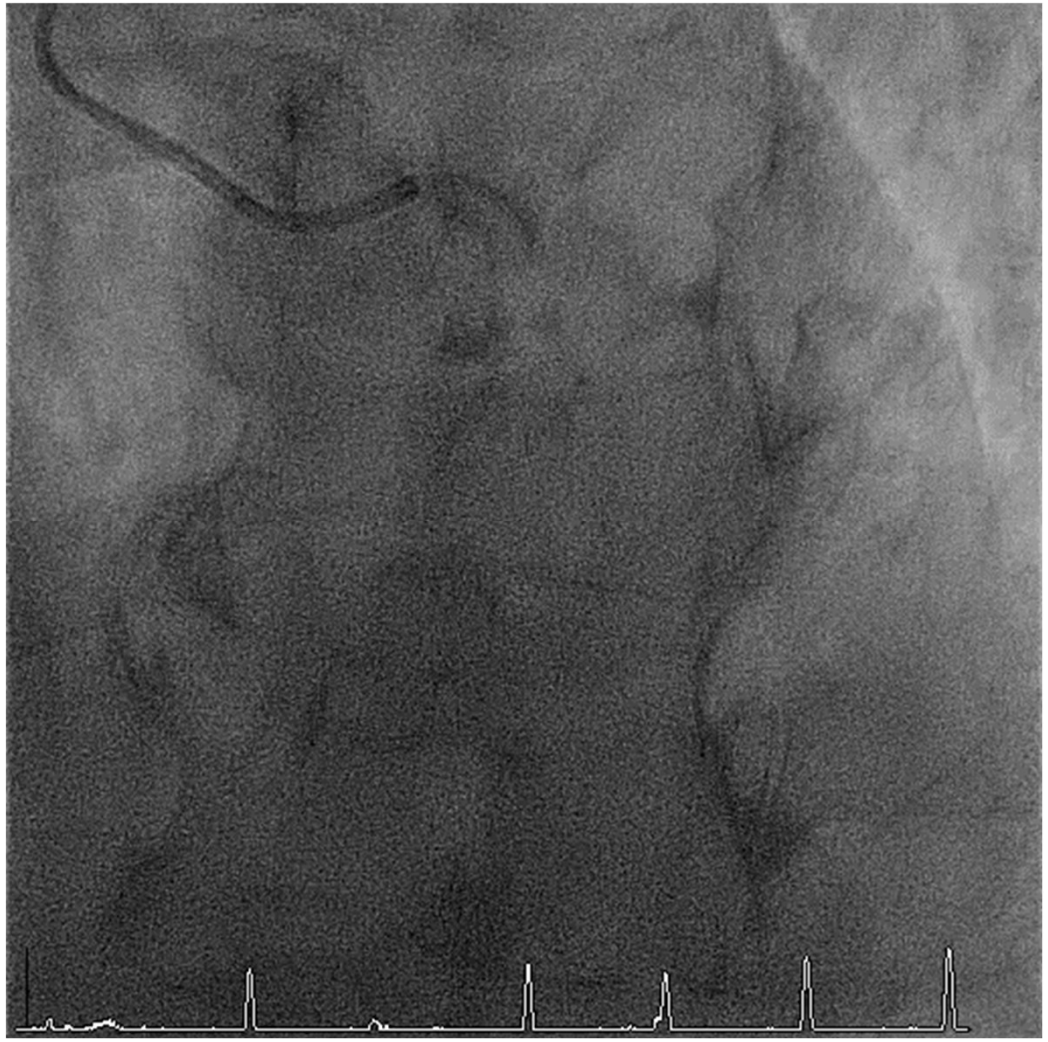
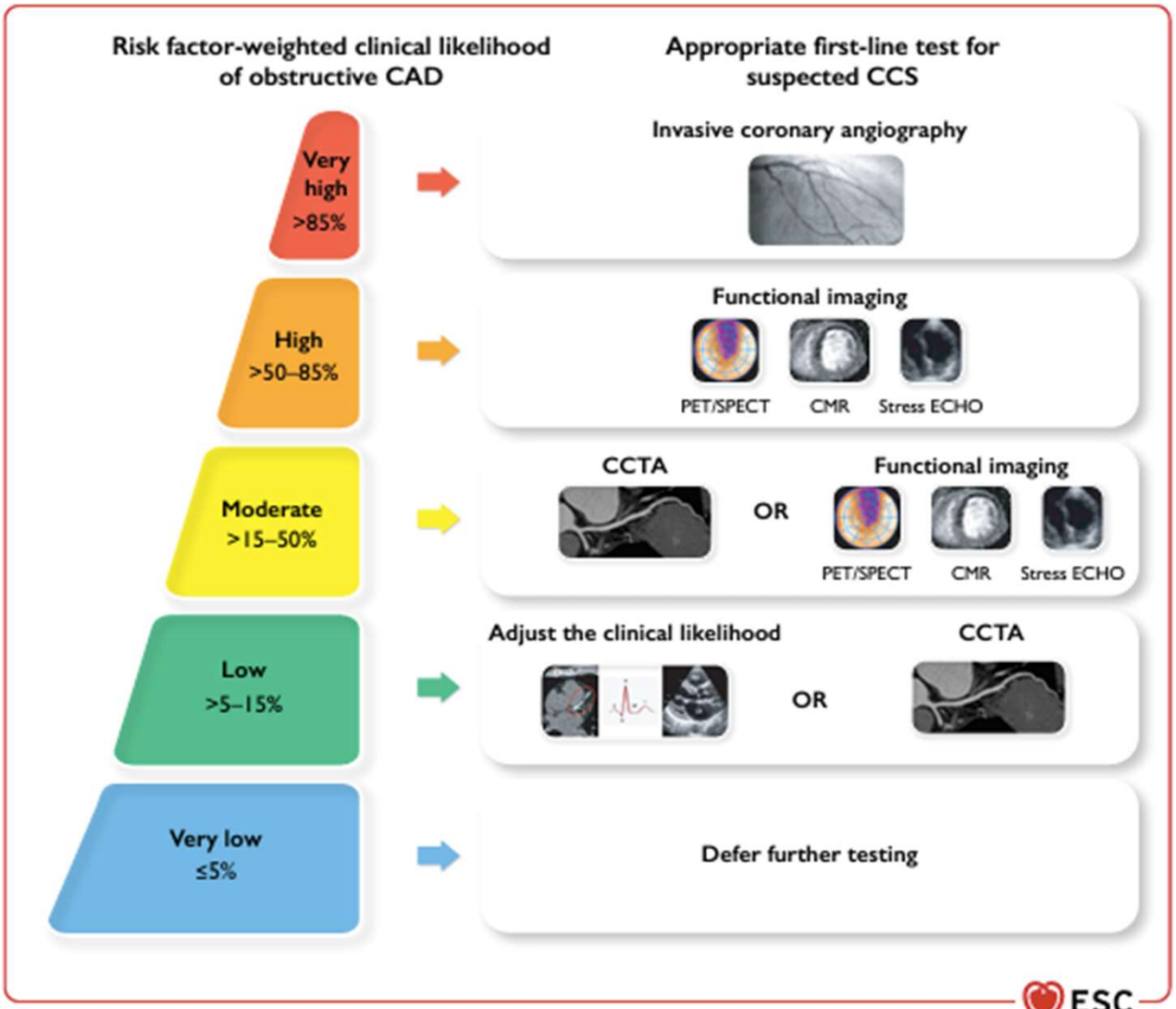


Myokardperfusions-PET – Beispiel



PET/SPECT/MRI

Recommendations	Class[a]	Level[b]
In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD, stress SPECT or, preferably, PET myocardial perfusion imaging is recommended to: • diagnose and quantify myocardial ischaemia and/or scar; • estimate the risk of MACE; • quantify myocardial blood flow (PET).[33,44,223,257,263,268,270,271,281–288]	I	B
In patients selected for PET or SPECT myocardial perfusion imaging, it is recommended to measure CACS from unenhanced chest CT imaging (used for attenuation correction) to improve detection of both non-obstructive and obstructive CAD.[289–293]	I	B
In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD, stress CMR perfusion imaging is recommended to diagnose and quantify myocardial ischaemia and/or scar and estimate the risk of MACE.[148,273,276,278,294–297]	I	B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Very low ≤5%
Defer further testing
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Wahl des passenden Testes

– Zusätzlich zur klinischen Wahrscheinlichkeit muss berücksichtigt werden:

- Expertise
- Verfügbarkeit
- Patientencharakteristika (z.B. unregelmässiger Puls, viel Kalk → kein CT)
- Andere Fragestellungen (Viabilität, Kardiomyopathie, Vitien…)
- Risiken durch Test: Strahlenbelastung, Kontrastmittel, medikamentöse Belastung

Wahl des passenden Tests

	Verfüg-barkeit	Kosten (CHF)	Strahlung	Tissue Char.	Stress	Koronarien	Viabilität
Echo	++++	750	-	++	+++	+	+
CMR	++	1300	-	++++	+++	+	+++
CCTA	+++	700	1-1.5mSv	(+)	-	++++	-
SPECT	+++	1500-2000	9-10mSv	-	++	-	+
PET	+	2500	3-4mSv	-	++++	-	+++

Take Home Messages

- Die Prävalenz der stenosierenden KHK bei Patienten mit Thoraxschmerzen/Dyspnoe ist noch deutlich tiefer als bislang angenommen
- Das Belastungs-EKG sollte aufgrund der tiefen Sensitivität und Spezifität nicht zur Ischämiediagnostik eingesetzt werden
- Vortestwahrscheinlichkeit wird seit 2024 anhand des Risk-Factor-weighted Clinical Likelihood (RF-CL) Modells erhoben
- Aufgrund der allgemein deutlich tieferen Vortestwahrscheinlichkeiten qualifizieren mehr Patienten für ein Koro-CT, welches eine KHK sehr gut ausschliessen kann

Stadtspital Zürich

Vielen Dank für die Aufmerksamkeit!

Dr. med. Muriel Wiedemann-Buser
Oberärztin meV Klinik für Kardiologie