

CARDIOPATIA ISCHEMICA

L'evoluzione della TC coronarica: dal burden aterosclerotico alla valutazione dell'ischemia

Cesareni Matteo



What's new?

AI based reconstruction

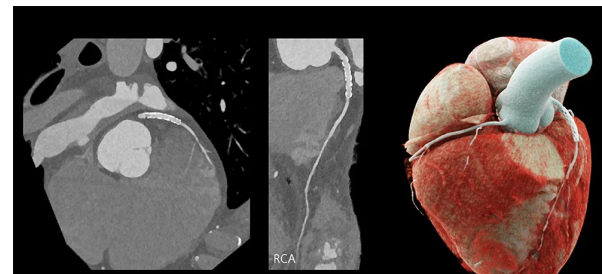
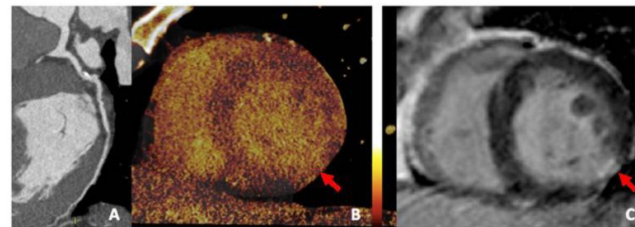
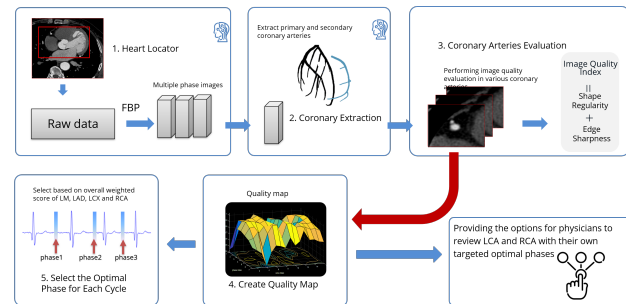
- best phase selection
- motion correction
- dose modulation

Dual-energy CT

- virtual monoenergetic
- virtual non-contrast
- iodine myocardial perfusion maps

Photon-counting CT

- spatial resolution
- soft-tissue contrast
- dose-efficient



1. C'è patologia aterosclerotica?

2. Quanta stenosi determina?

Non-invasive anatomical imaging tests in the initial diagnostic management of individuals with suspected obstructive coronary artery disease—coronary computed tomography angiography, if available and supported by local expertise—Section 3

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.

I

A

Selection of individual diagnostic tests in individuals with suspected chronic coronary syndrome—Section 3

To rule out obstructive CAD in individuals with low or moderate (>5%–50%) pre-test likelihood, CCTA is recommended as the preferred diagnostic modality.

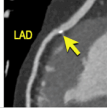
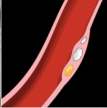
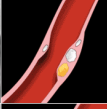
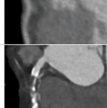
I

B

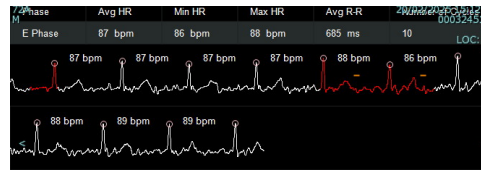
CCTA is recommended in individuals with low or moderate (>5%–50%) pre-test likelihood of obstructive CAD if functional imaging for myocardial ischaemia is not diagnostic.

I

B

Cad-Rads	Stenosis	CT imaging	Illustration	Additional Tests
Cad-Rads 0	0% No stenosis			None
Cad-Rads 1	1-24% Minimal stenosis			None
Cad-Rads 2	25-49% Mild stenosis			None
Cad-Rads 3	50-70% Moderate stenosis			Consider functional assessment
Cad-Rads 4	A: 70-99% stenosis in 1 or 2 vessels B: >50% stenosis in the left main or >70% stenosis in 3-vessels			A: Consider functional assessment or ICA B: ICA is recommended
Cad-Rads 5	100% total occlusion			ICA and/or viability assessment

Valutazione anatomica

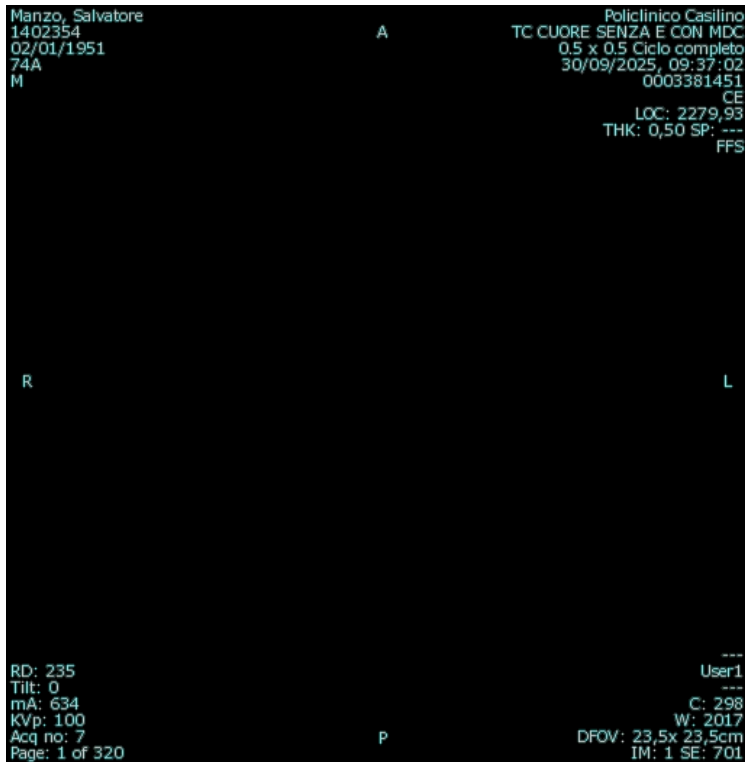
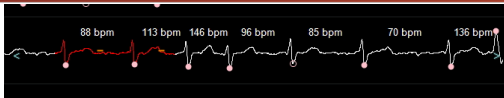


**Deep learning
reconstruction**

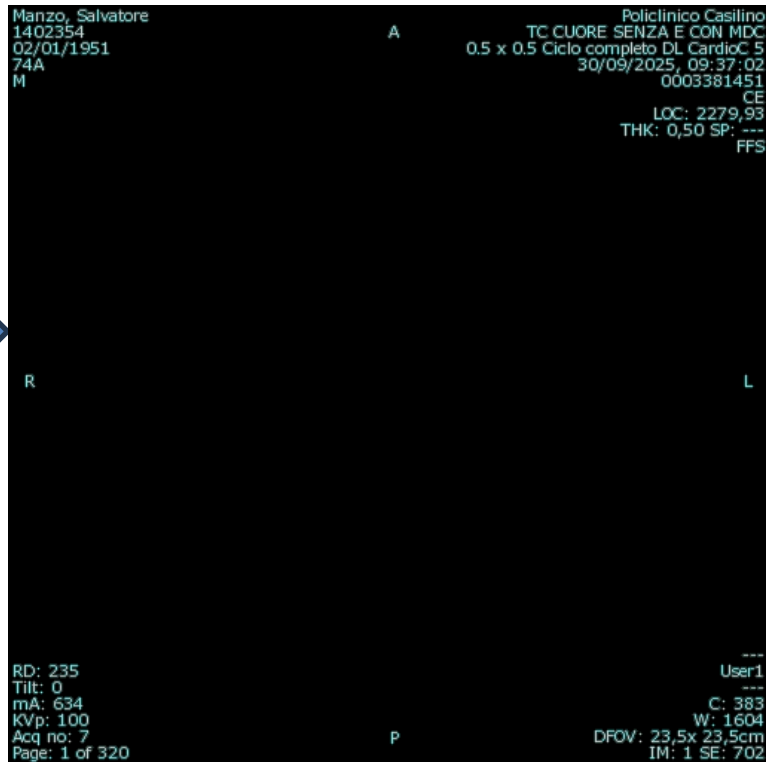
Esiti della lesione

Diramazi...	ID lesione	Tipo	Stenosi % (...)	Stenosi % (...)	Distanza dall'ingresso d...	Volume(...)	Calcifica...	Fibra (...)	Lipidi...
LAD	Lesione_1	N.A.	73	66	N.A.	N.A.	N.A.	N.A.	N.A.
LAD	Lesione_2	Placca ca...	75	65	49.9	32.3	100.0	0.0	0.0

Valutazione anatomica



Deep learning
reconstruction



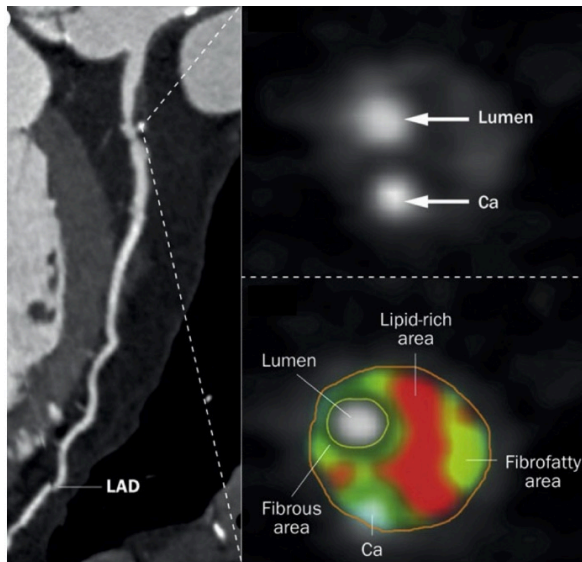
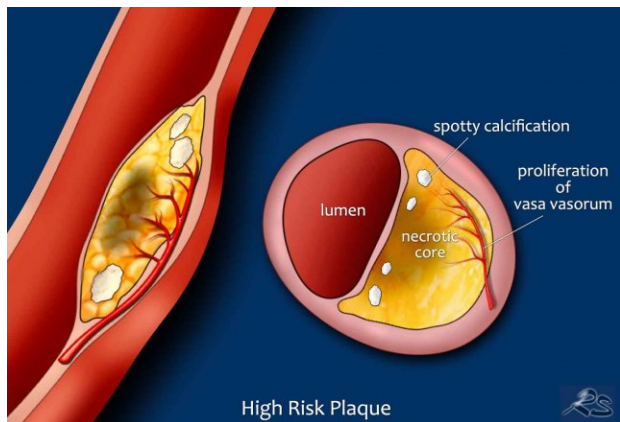
La placca è vulnerabile?

- SCOT-HEART e CAPIRE:

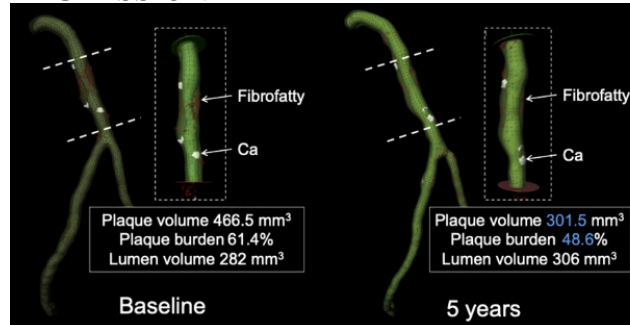
Valore prognostico delle caratteristiche di placca

- PARADIGM:

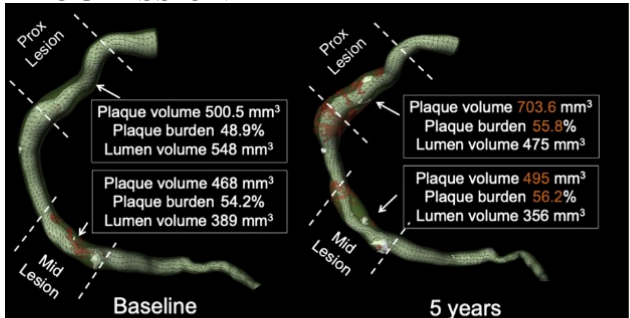
Valutazione della **risposta alla terapia**



REGRESSIONE



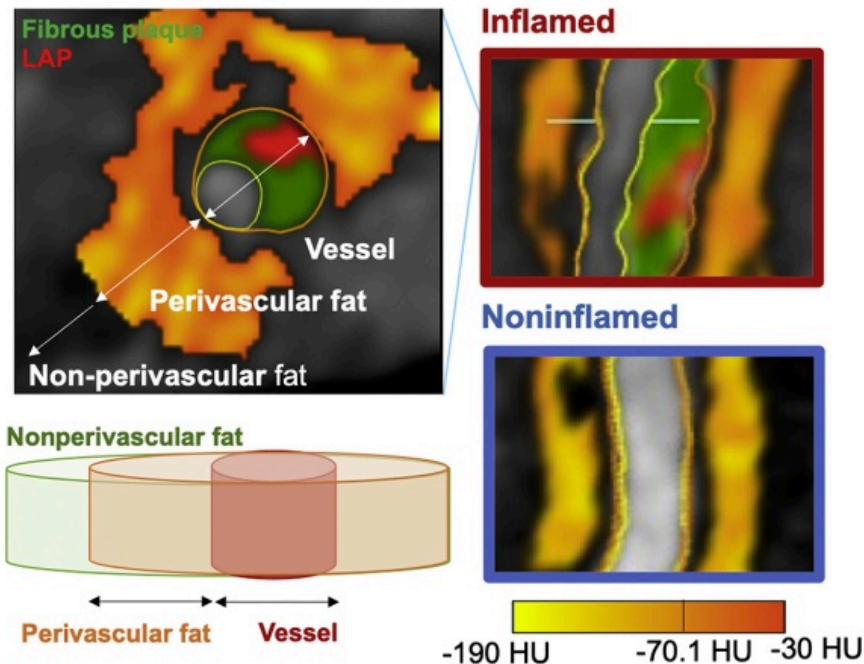
PROGRESSIONE



Caratterizzazione di Placca

Tessuto adiposo pericoronarico

**Vascular inflammation sensing by perivascular fat
(Perivascular fat attenuation index)**



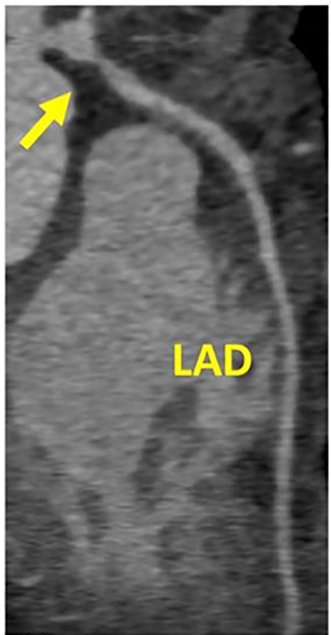
Studio CRISP-CT:

Il grasso pericoronarico infiammato influiva significativamente sulla **mortalità cardiaca**, anche nei pazienti senza placche ad alto rischio.

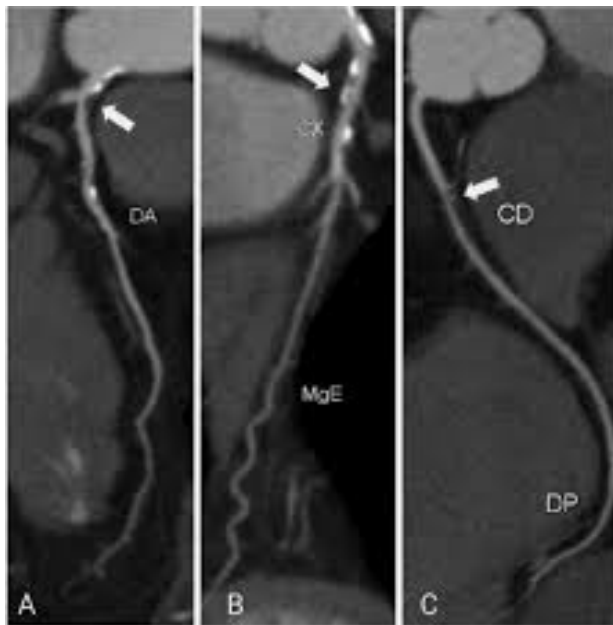


Plaque burden

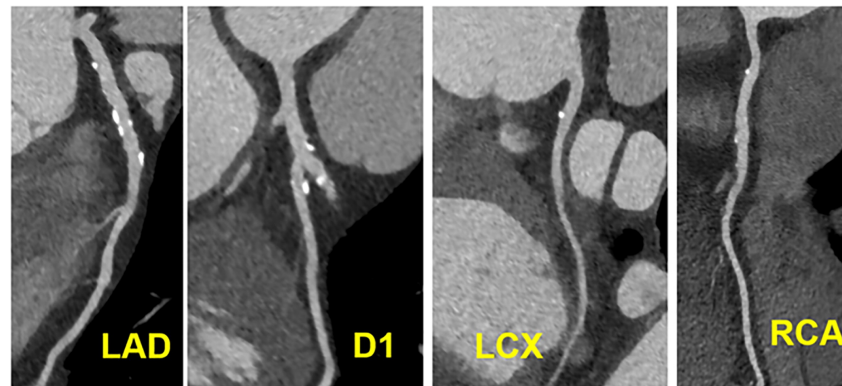
Quanto è estesa la patologia?



CAD-RADS 4/P1



CAD-RADS 3/P4



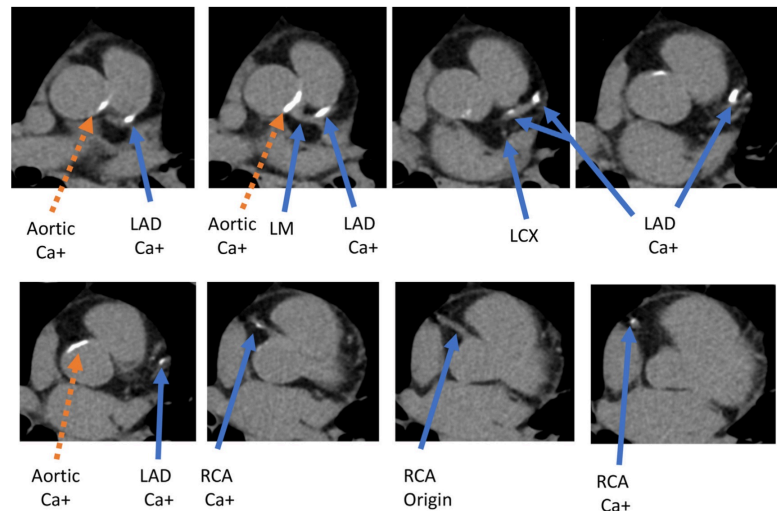
CAD-RADS 1/P3



Plaque burden

Calcium Score: Calcified Plaque Burden

- Stratificazione del rischio
- Stima il carico lesionale calcifico
- Si possono utilizzare anche pregresse TC torace
- Integrazione ai test funzionali



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.

Screening for coronary artery disease in asymptomatic individuals—Section 5

When coronary artery calcification findings are available from previous chest CT scans, using these findings to enhance risk stratification and guide treatment of modifiable risk factors should be considered.

Coronary artery calcium scoring (CACS) may be considered to improve risk classification around treatment decision thresholds.

I

B

IIa

C

IIb

C

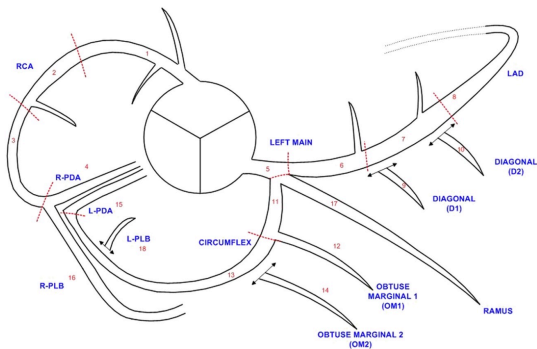


Plaque burden

Total plaque burden

CAD-RADS P modifier

	Amount of plaque	Calcium score	SIS*
P1	Mild	1-100	≤2
P2	Moderate	101-300	3-4
P3	Severe	301-999	5-7
P4	Extensive	>1000	≥8



CT Leaman Score

Localization of the Coronary Plaques			
Coronary Segments	Right Dominance	Left Dominance	Balanced
RCA			
RCA proximal	1	0	0.5
RCA mid	1	0	0.5
RCA distal	1	0	0.5
PDA	1	NA	0.5
PL branch	0.5	NA	NA
Left main	5	6	5.5
LAD			
LAD proximal	3.5	3.5	3.5
LAD mid	2.5	2.5	2.5
LAD distal	1	1	1
1st diagonal	1	1	1
2nd diagonal	0.5	0.5	0.5
LCX			
LCX proximal	1.5	2.5	2
Intermediate branch	1	1	1
1st obtuse marginal	1	1	1
2nd obtuse marginal	1	1	1
LCX distal	0.5	1.5	1
PL branch	NA	0.5	0.5
PDA	NA	1	NA

Type of Plaque

- Noncalcified and mixed plaques: 1.5
- Calcified plaques: 1

Noncalcified



Calcified



Degree of Stenosis

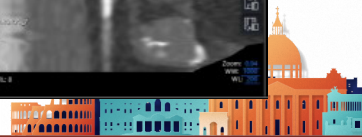
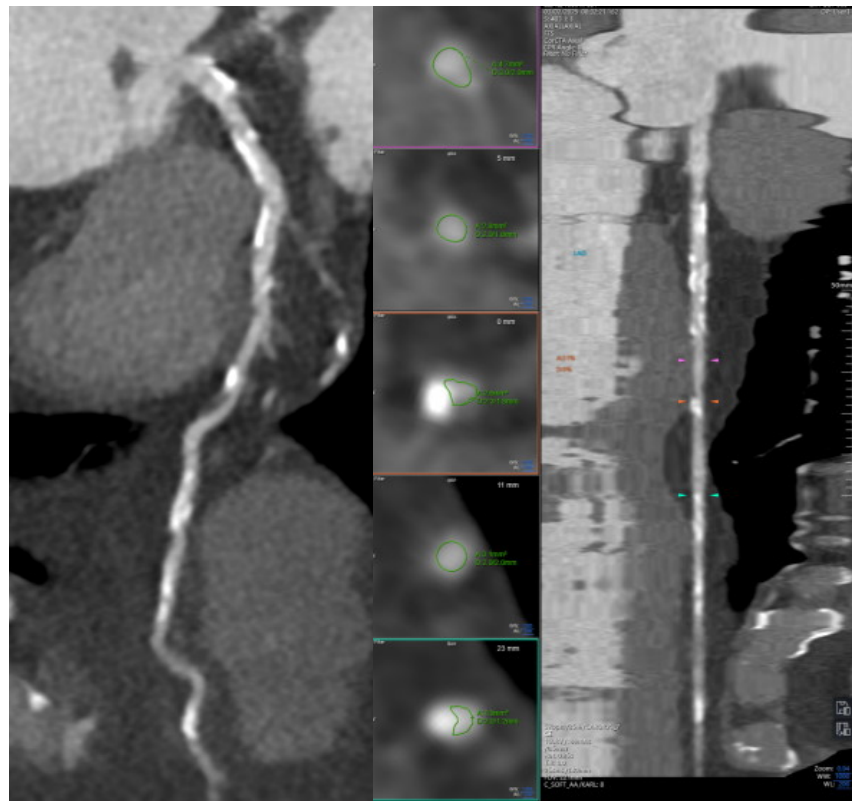
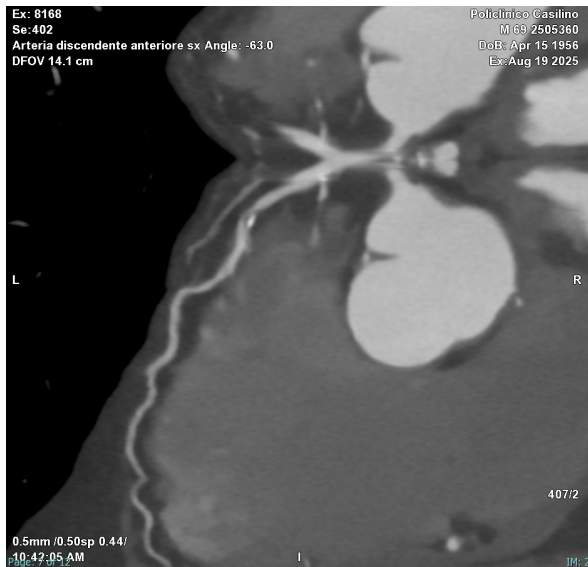
- Obstructive (≥50% stenosis): 1
- Nonobstructive (<50% stenosis): 0.615



CT-Leaman score >5 ma **senza stenosi ostruttive** avevano una sopravvivenza libera da eventi cardiaci maggiori **simile** a quella dei pazienti con stenosi ostruttive

1. La placca determina ischemia?
2. Quale placca trattare?

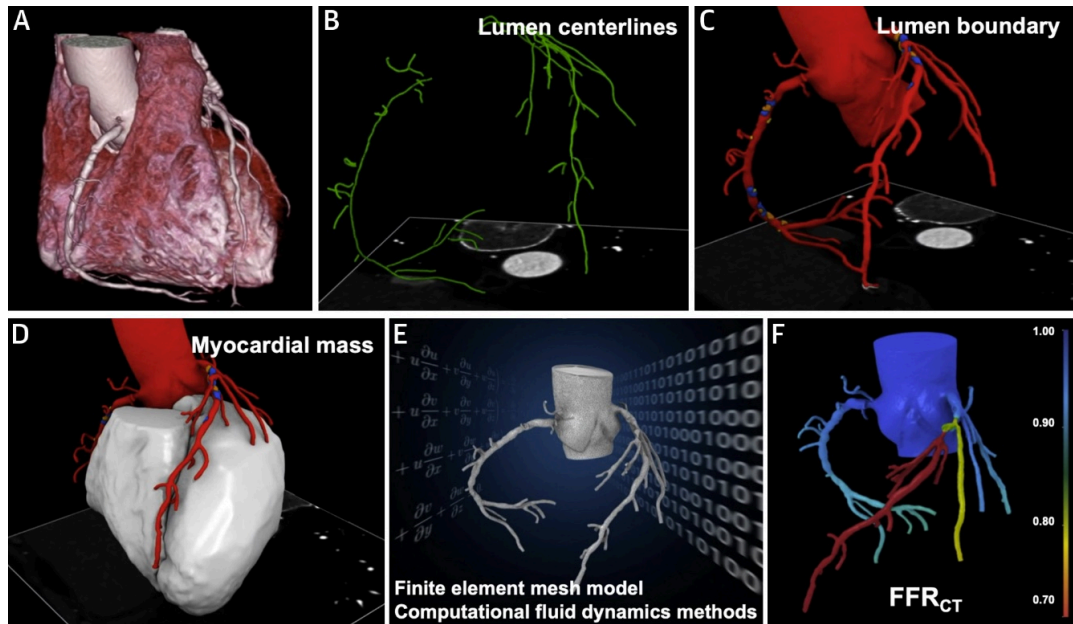
FFR-CT e Perfusion CT



Valutazione funzionale

FFR-CT

- Valutazione emodinamica
- Non necessita di ulteriori acquisizioni
- La FFR-CT non è un sostituto universale degli altri test funzionali, ma un gatekeeper dopo CCTA nei casi anatomici intermedi o dubbi.



In patients with a known intermediate coronary artery stenosis in a proximal or mid coronary segment on CCTA, CT-based FFR may be considered.

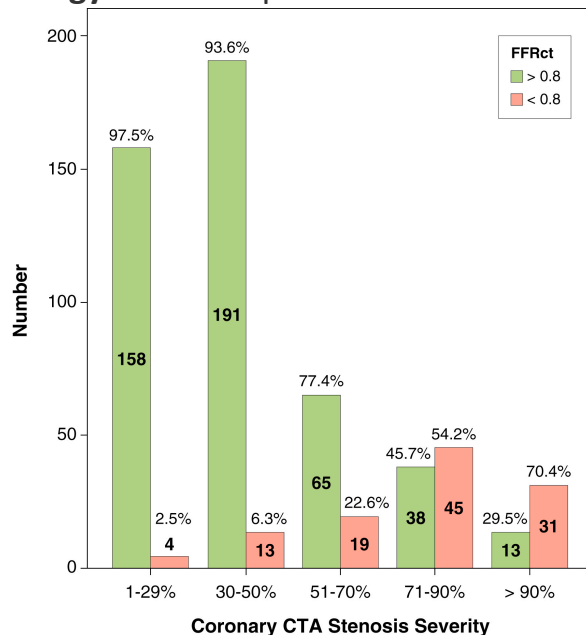


Valutazione funzionale

FFR-CT

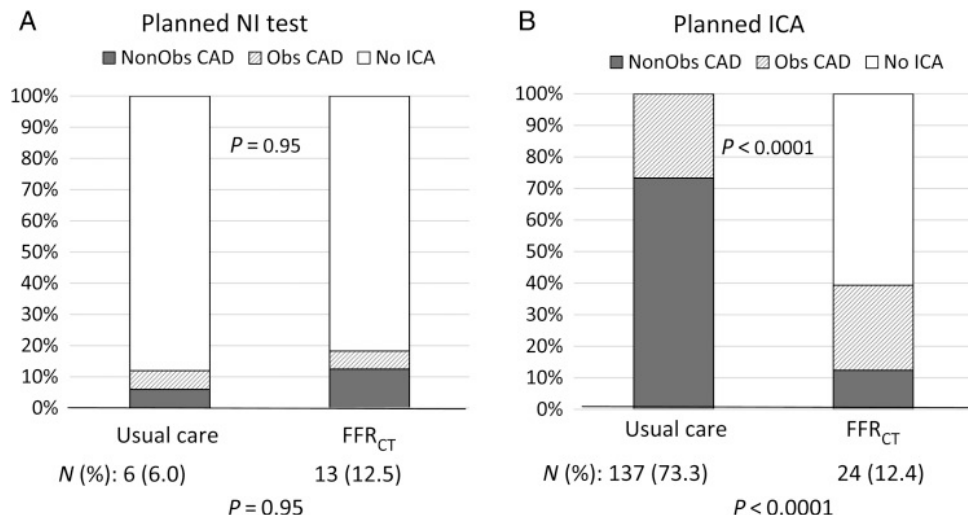
RIPCORD STUDY :

FFR_{CT} data resulted in a **change of the treatment strategy** in 36% of patients.



PLATFORM STUDY :

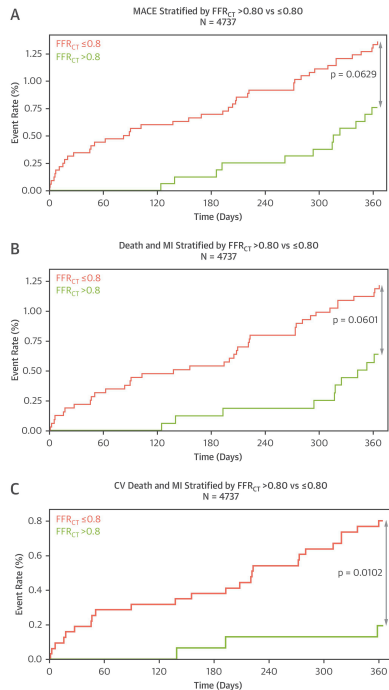
FFR_{CT} act as a gatekeeper to ICA, **reducing unnecessary negative interventions** in patients without obstructive CAD.



FFR-CT

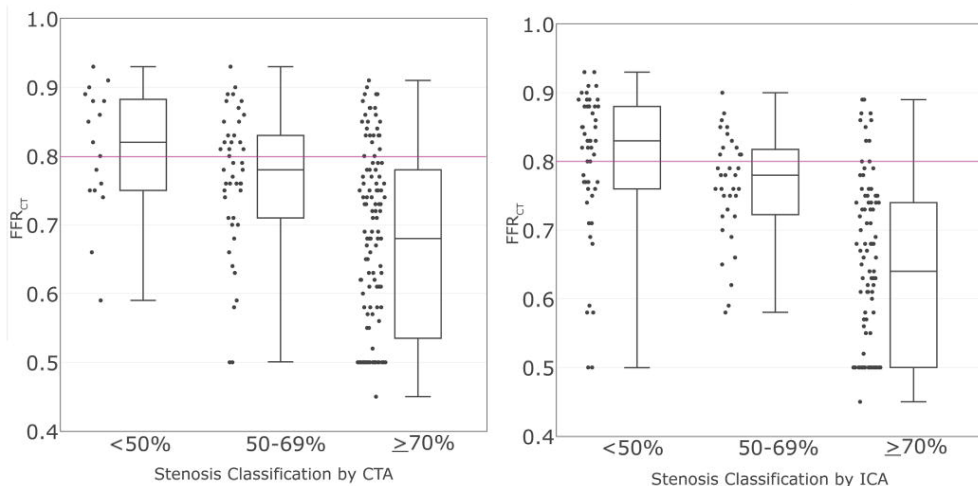
ADVANCE STUDY :

Low rates of events in with a negative FFR_{CT} compared with patients with abnormal FFR_{CT} values.

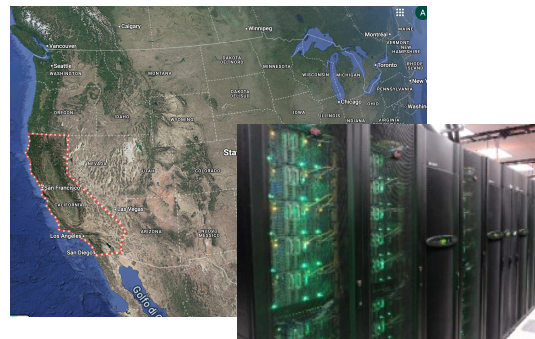
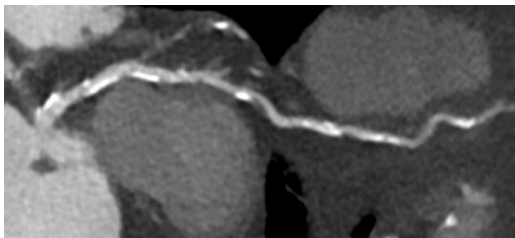


PROMISE STUDY :

FFR_{CT} ≤ 0.80 was a **better predictor of revascularization or MACE** than severe stenosis on CTA.



OFF-site FFR-CT



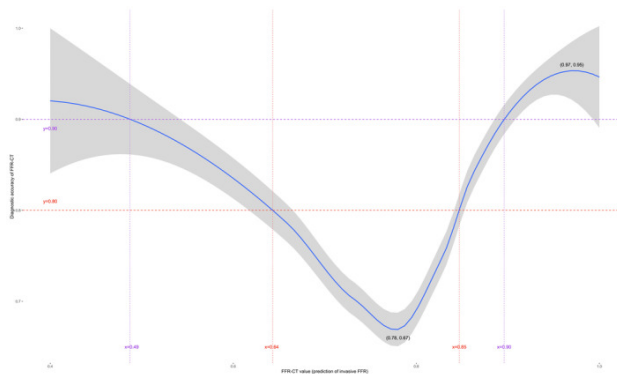
Diagnostic accuracy 79.4%

Journal of the American Heart Association

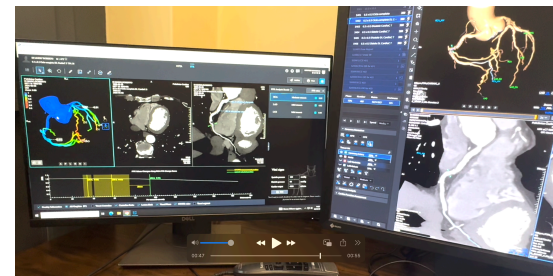
ORIGINAL RESEARCH

Agreement of Fractional Flow Reserve Estimated by Computed Tomography With Invasively Measured Fractional Flow Reserve: A Systematic Review and Meta-Analysis

Thomas I. Faulder, MD, PhD; Kurundeniya Premaratne, MD, PhD; Soniah B. Molo, MD; Lauren E. Faulder, MD; Rhonda Jones, MD; Joseph V. Moxon, MD



ON-site FFR-CT



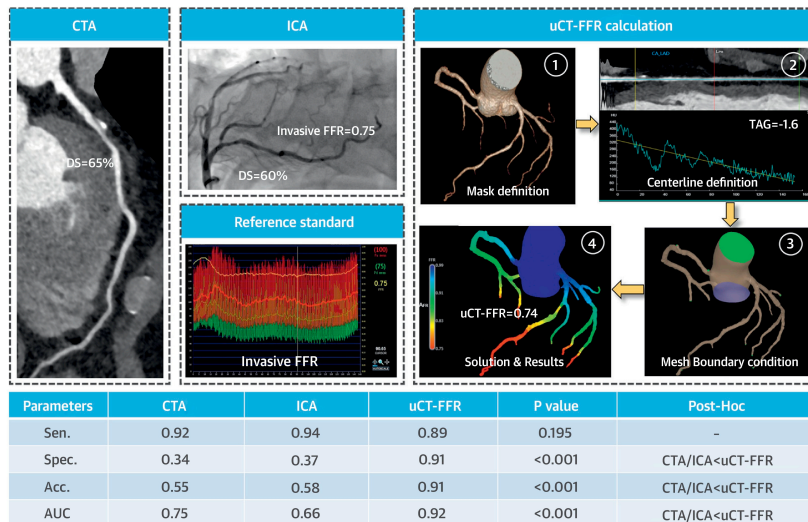
Diagnostic accuracy 84.1%.



ON-site FFR-CT

- Real-time analysis
- Integration into workflow
- Physician-driven
- Emergency setting

CENTRAL ILLUSTRATION: The Functional Significance of Proximal Left Anterior Descending Coronary Artery Stenosis With Mixed Coronary Plaque Was Analyzed Using Computed Tomographic Angiography, Invasive Coronary Angiography, and uCT-FFR



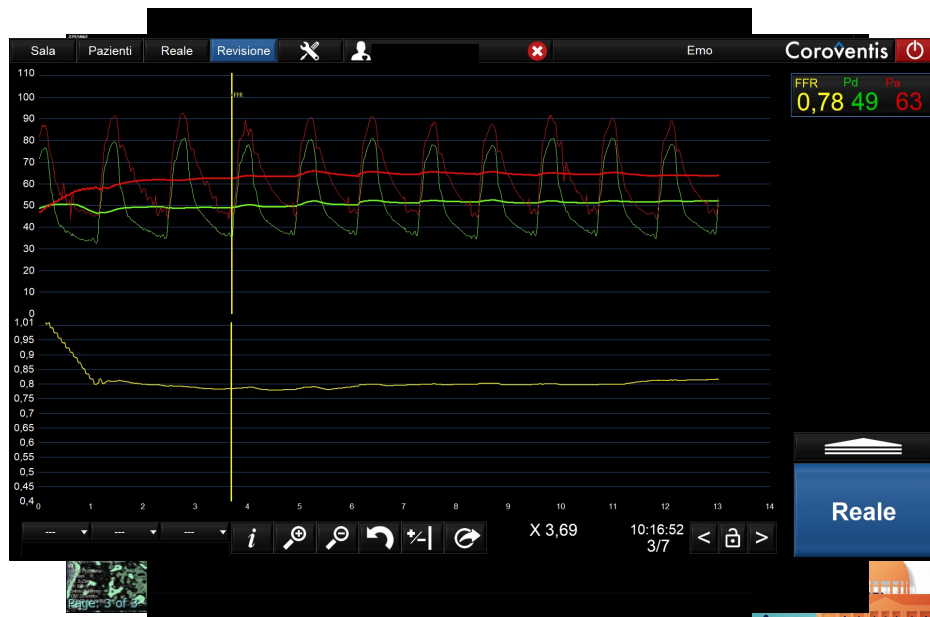
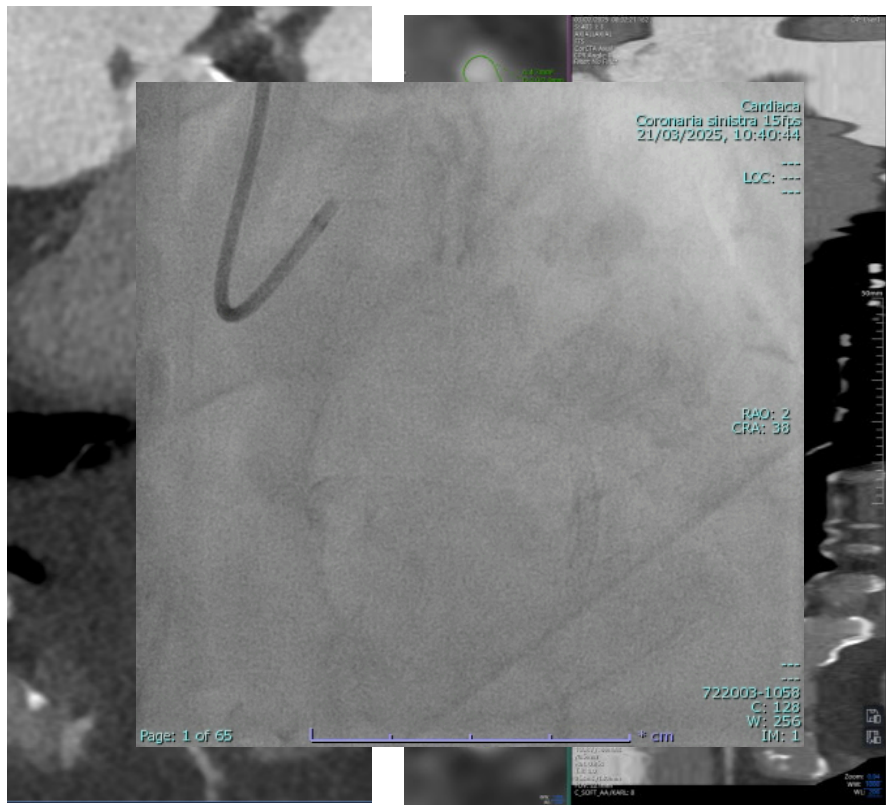
Tang, C.X. et al. J Am Coll Cardiol Img. 2020;13(4):980-90.



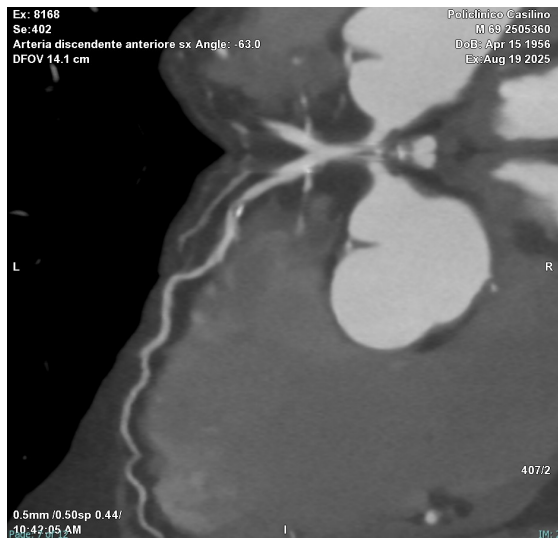
66 y men

Stable chest pain

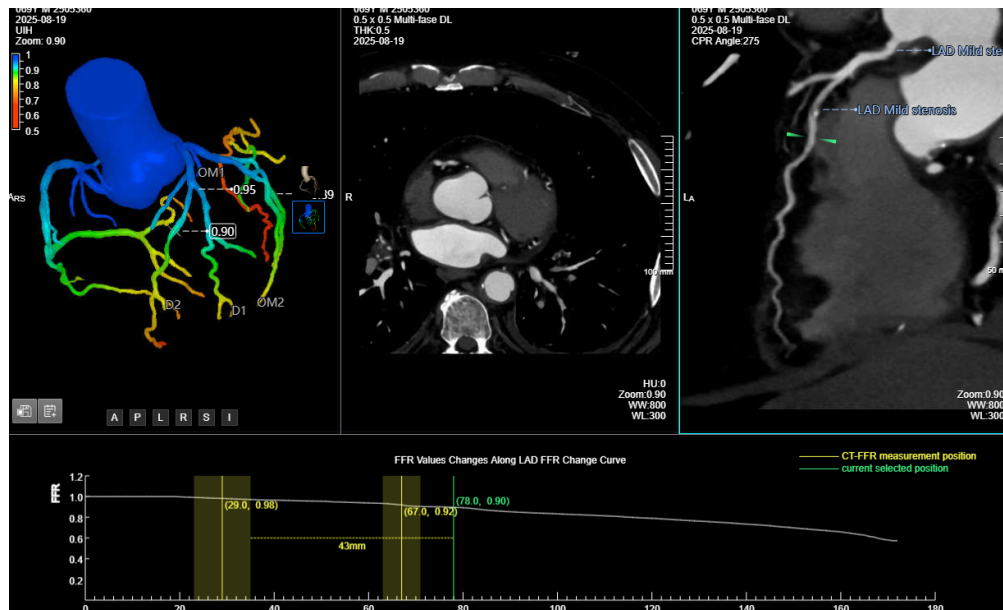
Multiple risk-factors for CAD



Men, 69y
Thoracic pain
Atrial Flutter
Hig pre-test risk for CAD
Emergency department



RCA	Mild stenosis	0.94
LAD	Mild stenosis	0.95
LCX	Normal	0.89



The American Journal of Cardiology

Volume 226, 1 September 2024, Pages 65-71



Late Outcomes of Patients in the Emergency Department With Acute Chest Pain Evaluated With Computed Tomography–Derived Fractional Flow Reserve

Jason Schott DO, Olivia Allen DO, Zachary Rollins MD, Elvis Cami MD, Kavitha Chinnaiyan MD, Michael Gallagher MD, Timothy A. Fonte MS, Abhay Bilolikar MD, Robert D. Safian MD

Perfusion-CT

In individuals with suspected CCS and moderate or high (>15%–85%) pre-test likelihood of obstructive CAD, CMR perfusion imaging is recommended to diagnose and quantify myocardial ischaemia and/or scar and estimate the risk of MACE.

I

B

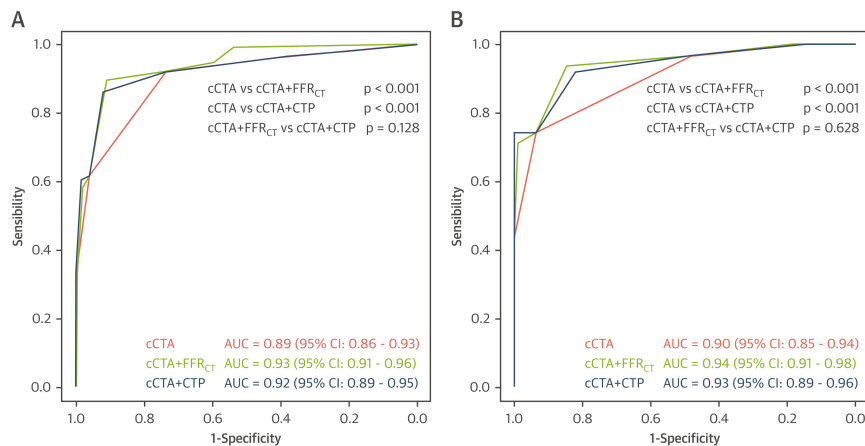
CRESCENT II STUDY :

Strategia TC integrata con **stress CT perfusion** nei casi con stenosi $\geq 50\%$ come **alternativa ai test funzionali tradizionali**

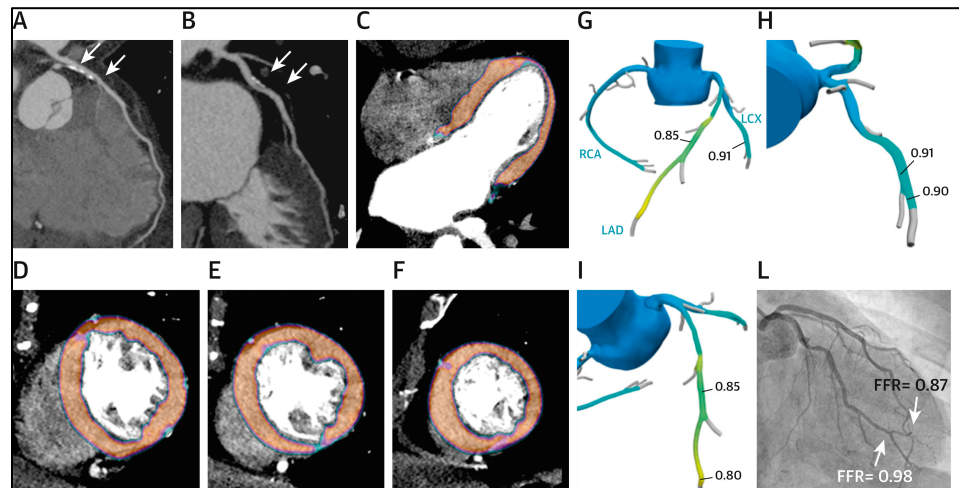


PERFECTION STUDY :

Equivalente performance diagnostica della CTA con CTP e della CTA con FFR-CT

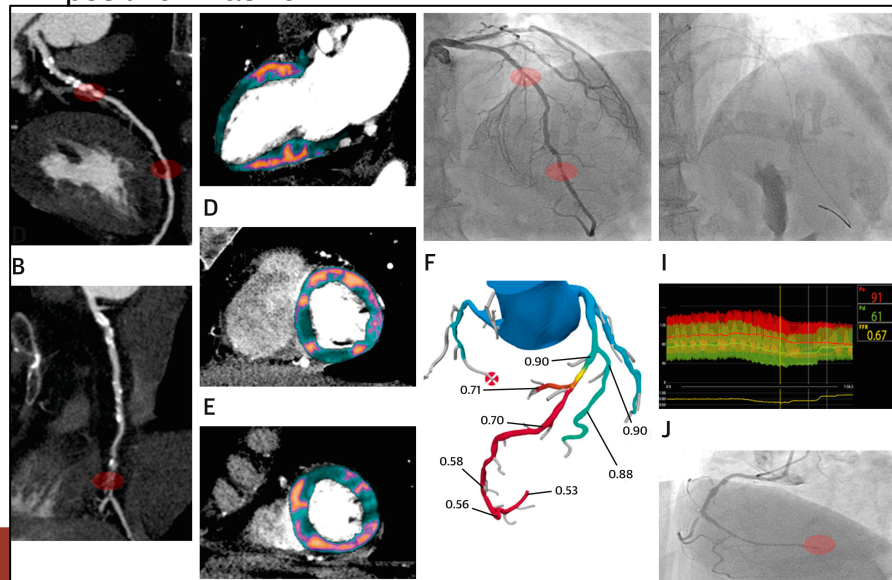


Valutazione funzionale



- chest pain, hypertension, dyslipidemia, positive exercise ECG
- Rest-cCTA shows a calcified stenosis of the proximal LAD & OM
- Stress-CTP showing normal myocardial perfusion.
- FFR_{CT} demonstrates normal values in the LAD and OM
- ICA shows mild LAD and OM stenoses with normal FFR

- hypertension, symptomatic for suspected angina, and inconclusive exercise-ECG test.
- CTA 2-vessel disease with moderate-to-severe stenoses of mid and distal LAD and occlusion of distal RCA
- stress-CTP inducible perfusion defect at the mid to distal antero-septal wall and basal inferior wall.
- FFR_{CT} shows pathology of value from mid LAD stenosis.
- ICA shows moderate mid and distal LAD stenoses with positive invasive FFR



Valutazione funzionale

Stessa piattaforma TC, due domande complementari:

La lesione limita il flusso?

FFR

- “Physiology inferred from anatomy”
- Valutazione vaso-specifica
- Stima la caduta pressoria
- Non richiede stress farmacologico.
- Non aggiunge dose/radiazioni
- Concettualmente è più simile alla FFR invasiva.
- Migliore per attribuire il significato funzionale a una singola lesione

Il miocardio va incontro a ischemia?

CT-Perfusion

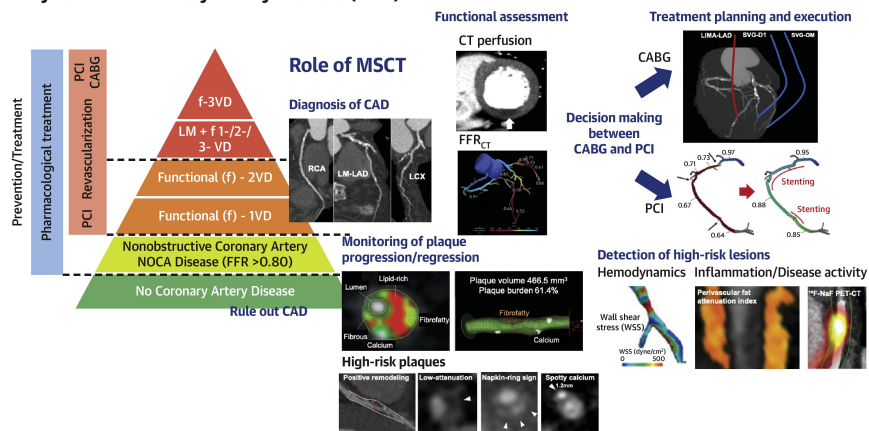
- “Ischemia directly visualized in the myocardium”
- Valutazione territorio-specifica
- Valuta il difetto di perfusione miocardica
- Richiede stress farmacologico
- Aggiunge dose e mezzo di contrasto
- Concettualmente è più simile a SPECT, PET o stress CMR
- Migliore per dimostrare l’effetto finale sul territorio miocardico.



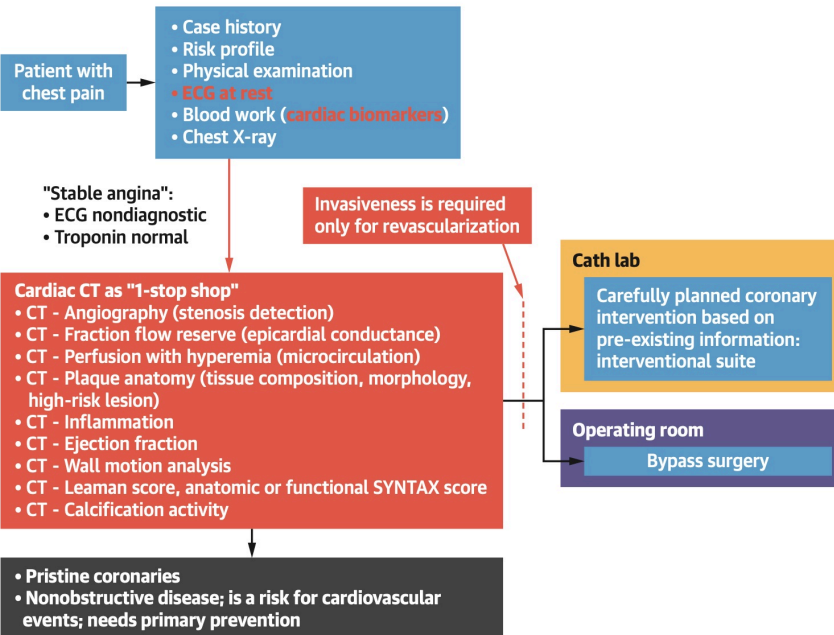
Cardio TC: one-stop shop

CENTRAL ILLUSTRATION: The Pyramid of Coronary Artery Disease and the Diagnostic Role of Multislice Computed Tomography

Pyramid of Coronary Artery Disease (CAD)



Serruys, P.W. et al. J Am Coll Cardiol. 2021;78(7):713-736.



Conclusioni

La TC dovrà rispondere contemporaneamente a diverse domande:

- ✓ C'è aterosclerosi?
- ✓ Quanta stenosi determina?
- ✓ Quanto è estesa?
- ✓ La placca è vulnerabile?
- ✓ Determina ischemia?
- ✓ Quale paziente beneficerà della rivascolarizzazione?

Take-home messages

- La TC coronarica non è più una metodica esclusivamente anatomica.
- L'integrazione tra burden aterosclerotico, caratteristiche di placca e valutazione funzionale migliora la stratificazione del rischio.
- L'evoluzione tecnologica (Dual Energy, Photon Counting e AI) renderà la TC sempre più uno strumento decisionale integrato.

