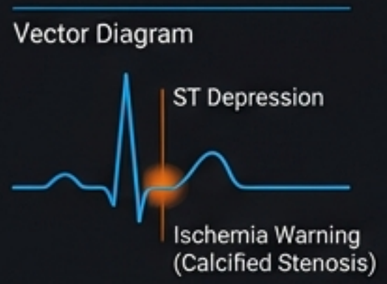
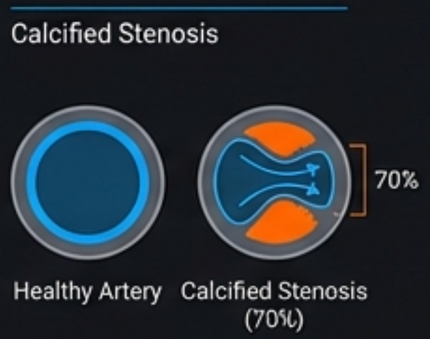
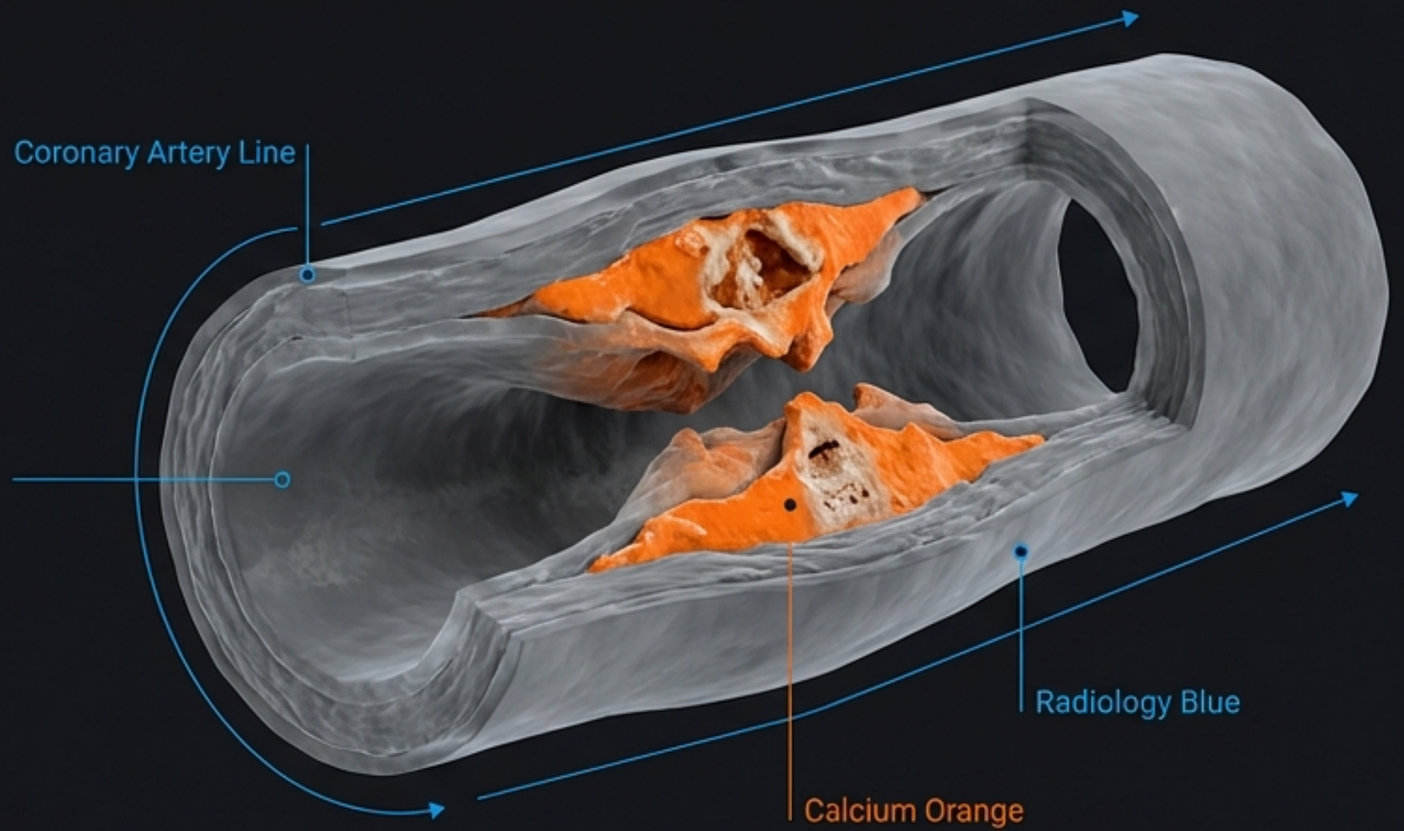
Coronary Artery Calcium: Clinical Risk and the Athletic Paradox

Moving from Probabilistic Models to Individualized Disease Visualization







Report by Dr. Peter Megdal

Executive Synthesis

The Paradigm Shift

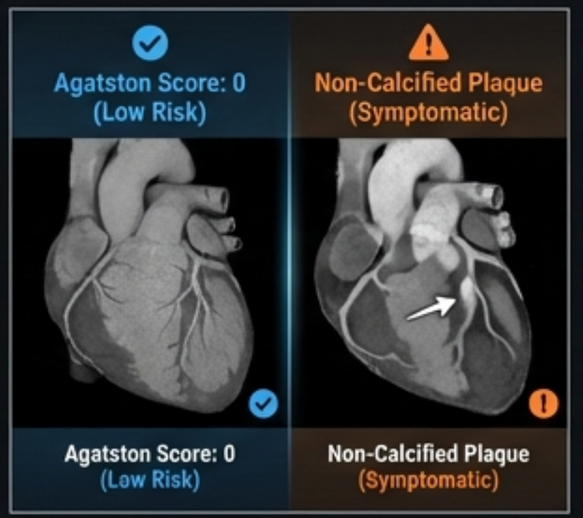
Moving beyond surrogate markers (cholesterol/BP) to direct visualization of atherosclerotic burden via Coronary Artery Calcium (CAC) scoring.

The Methodology

Utilizing non-contrast, ECG-gated CT and the Agatston scoring method to quantify calcified plaque volume and density.

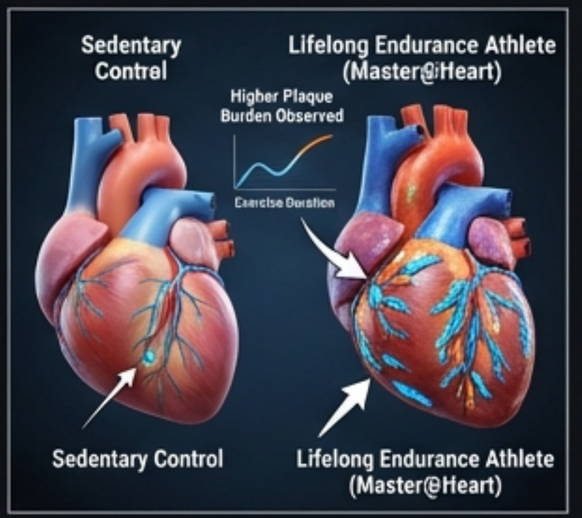
The 'Power of Zero' & Limits

Agatston 0 implies low near-term risk in asymptomatic patients but does not rule out non-calcified plaque in symptomatic individuals.



The Athletic Paradox

Evidence from Master@Heart reveals lifelong endurance athletes often exhibit higher plaque burdens than sedentary controls, challenging the linear "exercise = heart health" model.



From Probability to Visualization

Old Paradigm: Probabilistic Models

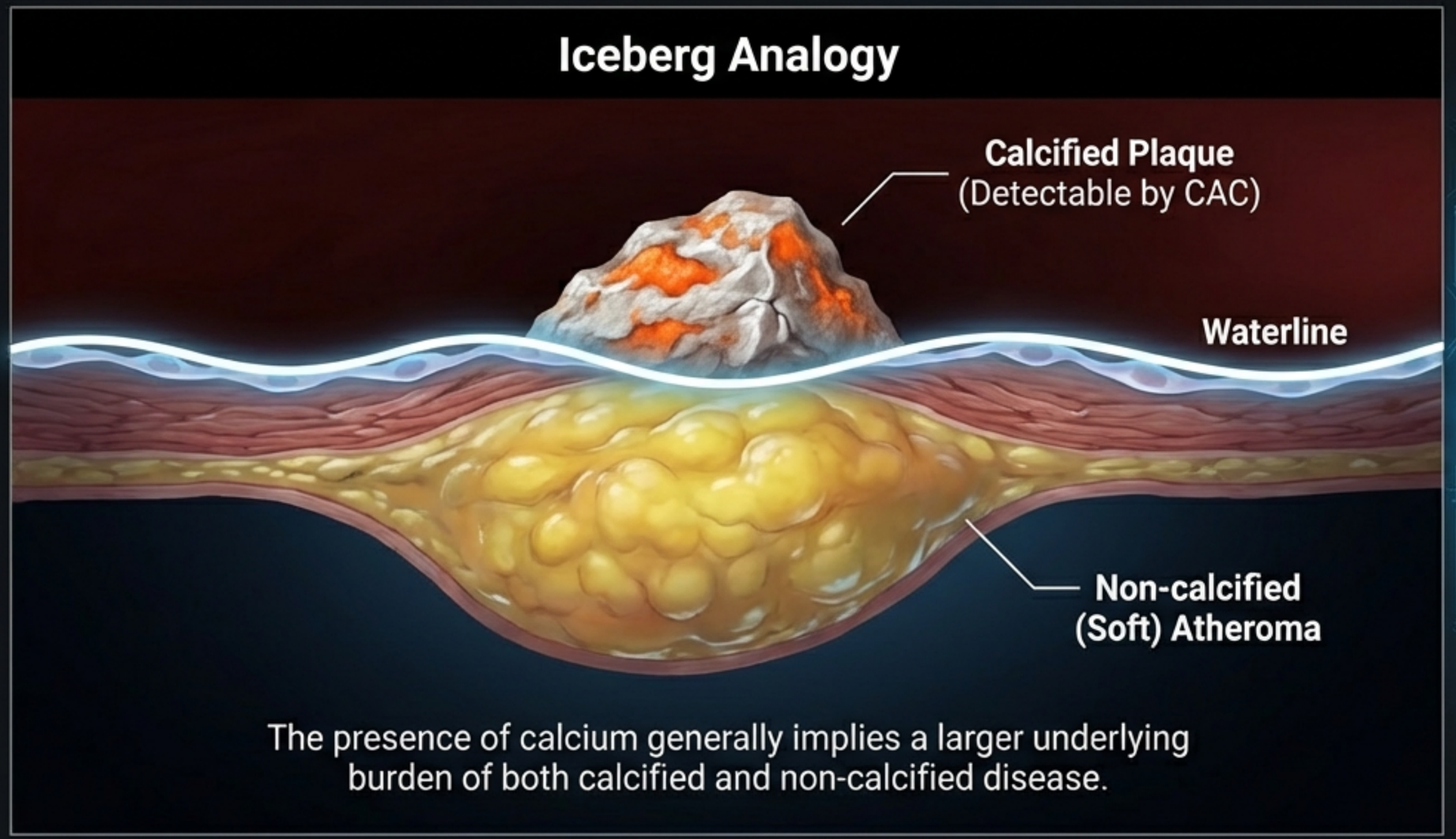
Basis: Indirect surrogate markers (Cholesterol, Blood Pressure, Diabetes).
Limitation: Estimates likelihood based on population averages, often misclassifying individual risk.

New Paradigm: Disease-Based Imaging

Basis: Direct visualization of atherosclerotic burden.
Advantage: Highly individualized risk stratification based on actual presence of disease.

Key Insight: CAC is a robust, independent predictor of myocardial infarction and cardiovascular mortality, outperforming traditional risk factors alone (Parikh et al., 2018).

CAC is an Active Biological Process



Definition

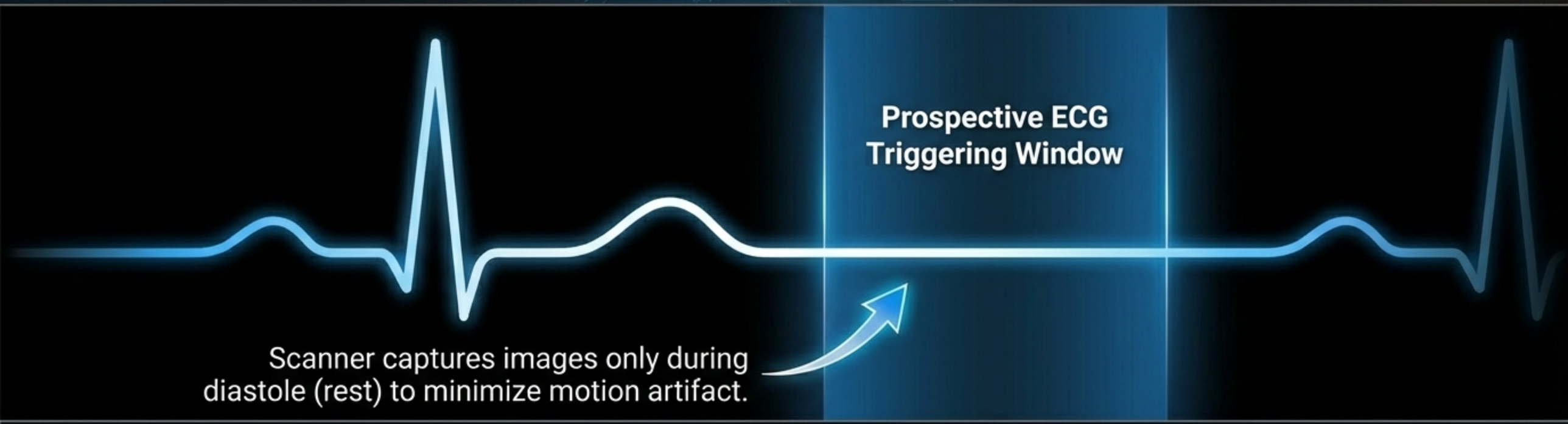
Coronary calcification is a regulated process, not a passive accumulation of minerals. It indicates the presence of advanced atherosclerosis.

Source

Blaha et al., 2023; Parikh et al., 2018.

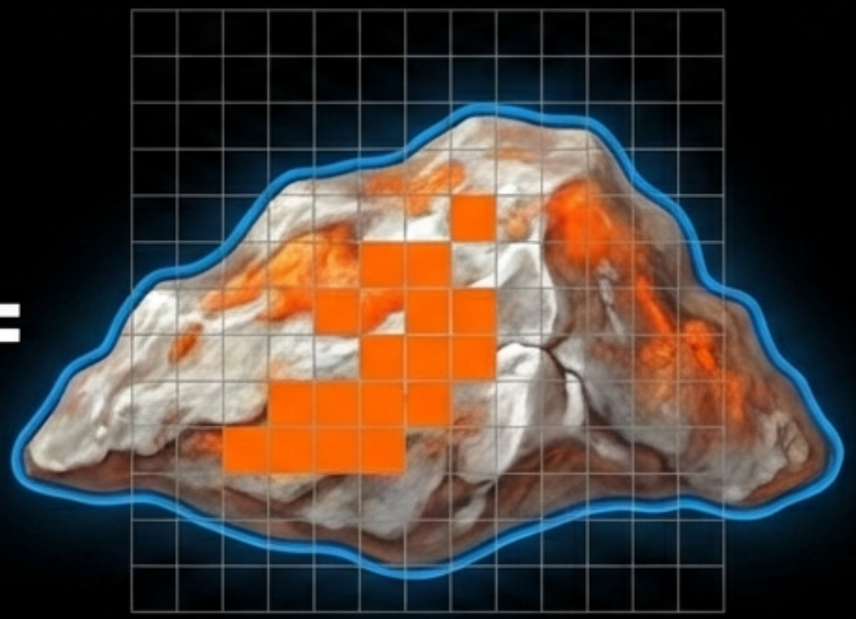
The Mechanics of Acquisition

- **Technique:** Non-contrast, ECG-gated Computed Tomography (CT).
- **Hardware Evolution:** Modern Multidetector CT (MDCT) has replaced Electron Beam CT (EBCT) due to higher spatial resolution and availability.



Calculating the Agatston Score

Score =



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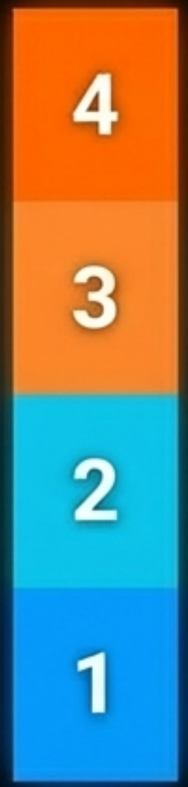

Lesion Area
(≥130 HU, ≥1mm²)

Density Factor
(1–4)

Density Factors:

130–199 HU = Factor 1

200–299 HU = Factor 2

300–399 HU = Factor 3

≥400 HU = Factor 4

Total Score is the sum of scores across the Left Main, LAD, LCx, and RCA.

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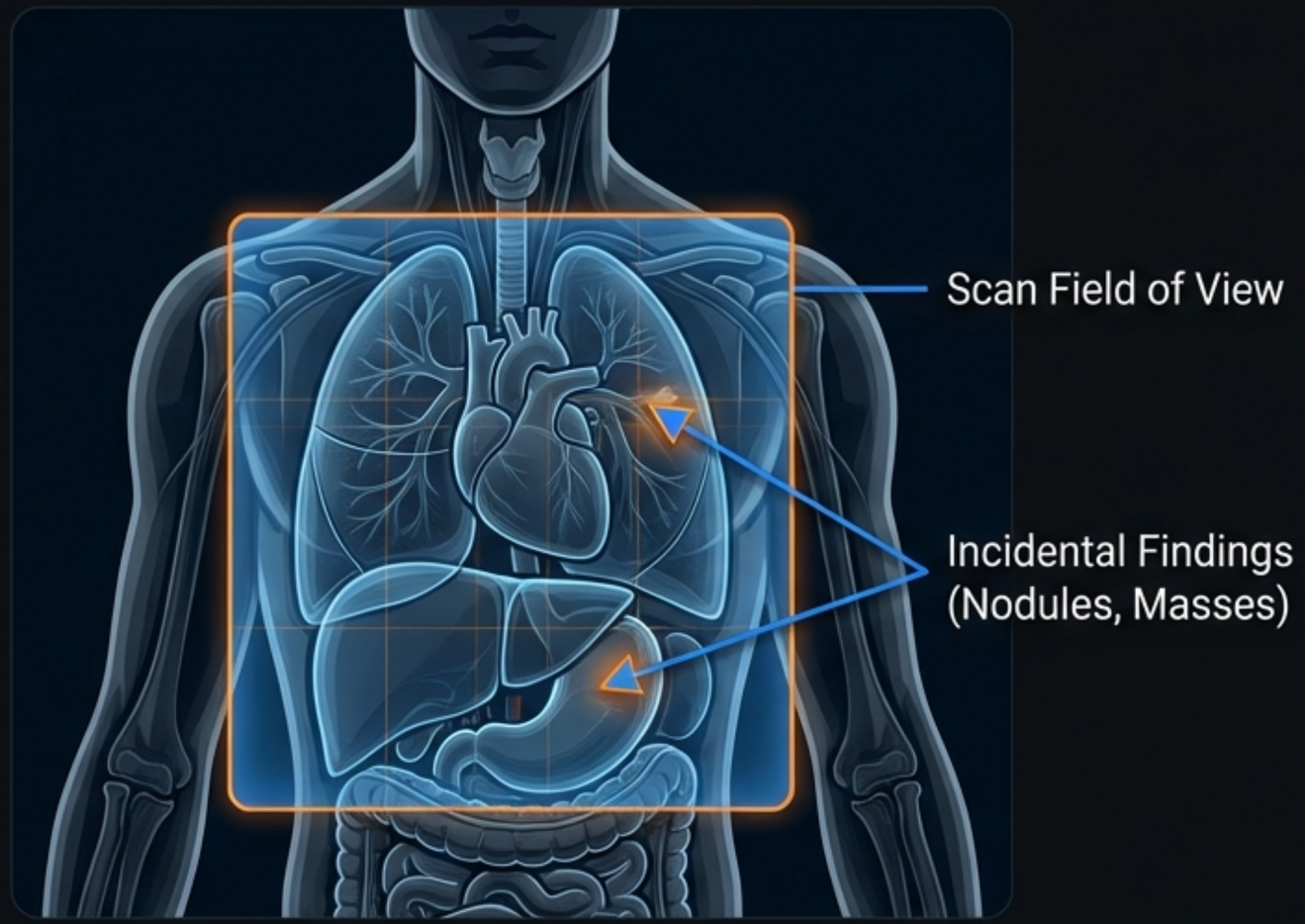
Safety, Radiation, and Scope

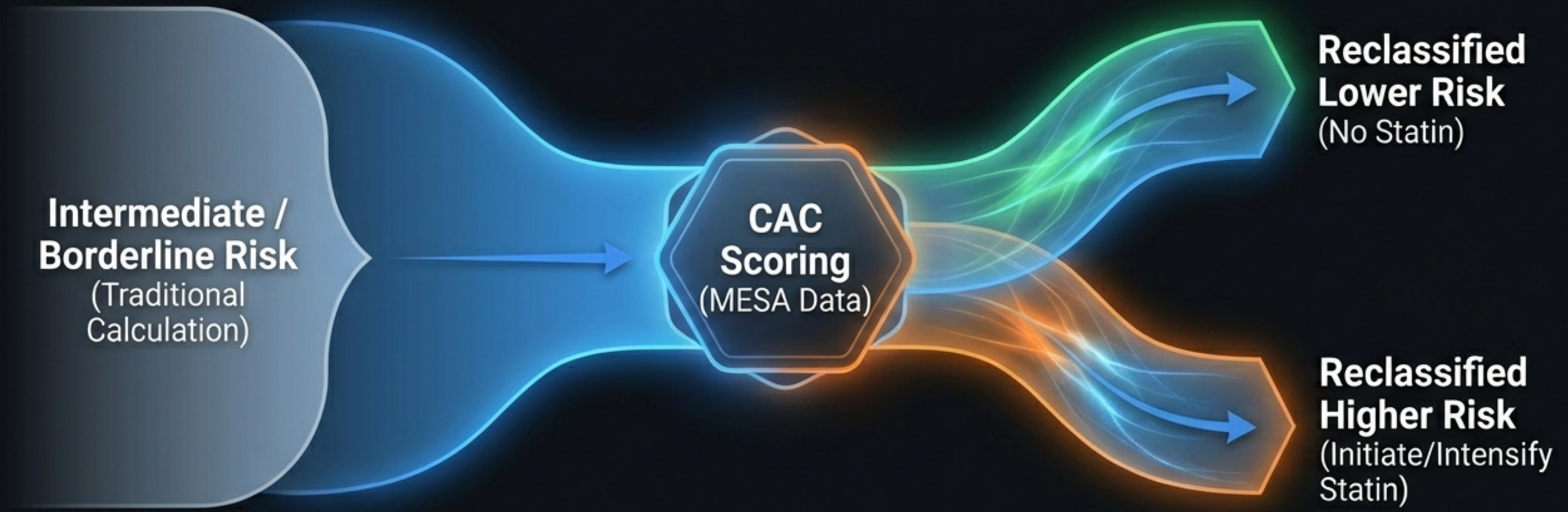


- **Radiation Profile:**
  Generally low dose.
  Typical contemporary protocols:
  ~1 mSv under optimized conditions.

- **Clinical Implication:**
  The scan captures extracardiac structures.
  Incidental findings are common and may require downstream testing.

Source: Kim et al., 2009; Hecht et al., 2024.

Predictive Power and Risk Reclassification



Primary Application: Refines risk assessment for patients in the "gray zone" where statin decisions are unclear. Validated by the Multi-Ethnic Study of Atherosclerosis (MESA).

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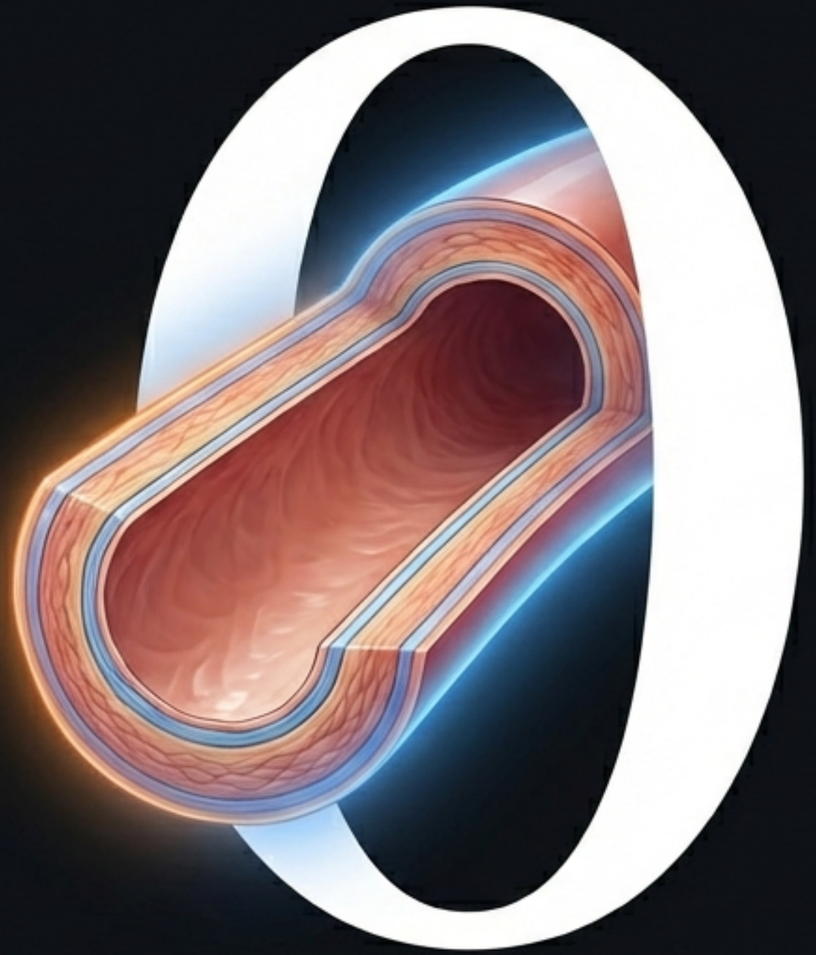
The Prognostic "Power of Zero"



- **Definition:**
  Agatston Score = 0
  (No detectable calcified plaque).
- **Meaning:**
  Associated with very low short-to-intermediate-term event rates in ASYMPTOMATIC adults.
- **Action:** Often supports downward risk reclassification.

Source: Grundy et al., 2019; Hecht et al., 2024.

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The Dangerous Gap: Why Zero ≠ Immunity

CONFIRM Registry Data: Symptomatic Patients with CAC=0

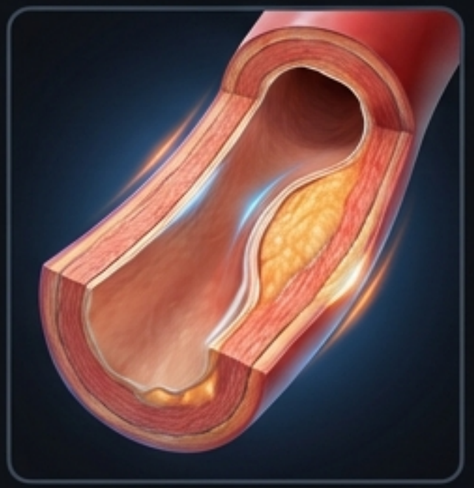
13% had nonobstructive CAD **13%**

3.5% had ≥50% stenosis

1.4% had ≥70% stenosis

In symptomatic patients, CAC=0 is NOT a definitive rule-out. It misses non-calcified (soft) plaque. Younger symptomatic patients are more likely to have non-calcified disease.

Villines et al., 2011; Mortensen et al., 2022.



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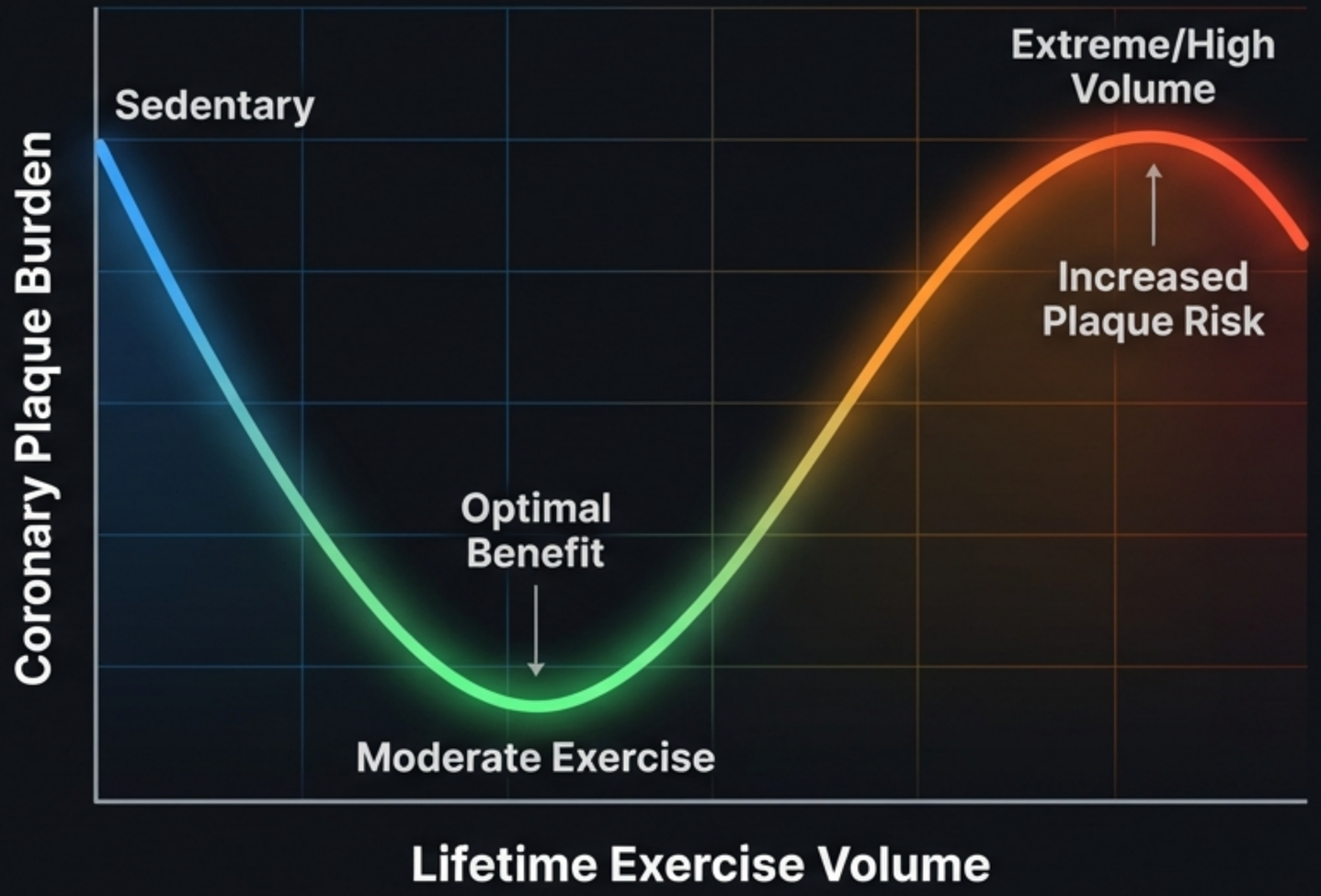
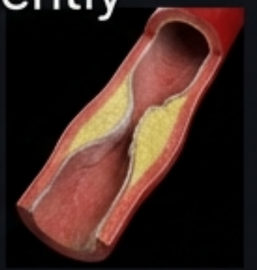
The Paradox of the Endurance Athlete



The Expectation:
Exercise = Heart Health

The Reality:
Masters athletes (>35y, high intensity) frequently exhibit higher CAC prevalence and plaque burden than sedentary controls



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Evidence from the Master@Heart Cohort

Control / Sedentary **Lifelong Endurance**

De Bosscher et al., 2023.

- Lifelong endurance exercise is associated with higher coronary atherosclerosis burden.
- Superior fitness does not grant immunity to plaque accumulation.
- High fitness does not shield against the formation of plaque.

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Interpreting the Athlete's Risk

The Nuance:
Despite higher CAC scores, outcomes in athletes are often favorable due to physiological buffers.

CLINICAL WARNING: Do NOT dismiss high CAC in an athlete as 'benign'. It represents real atherosclerosis and demands risk factor management.

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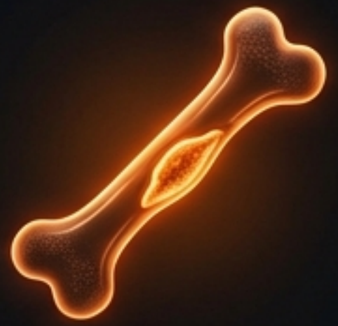
Selecting the Right Tool: CAC vs. CCTA

CAC (Non-Contrast CT)	CCTA (Angiography)
	
Best For Asymptomatic Risk Stratification	**Best For** Symptomatic Evaluation (Chest Pain)
✓ **Pros:** Low radiation, No contrast, Low cost. ✗ **Cons:** Misses non-calcified plaque.	✓ **Pros:** Visualizes soft plaque & obstruction. ✗ **Cons:** Requires contrast, higher complexity.

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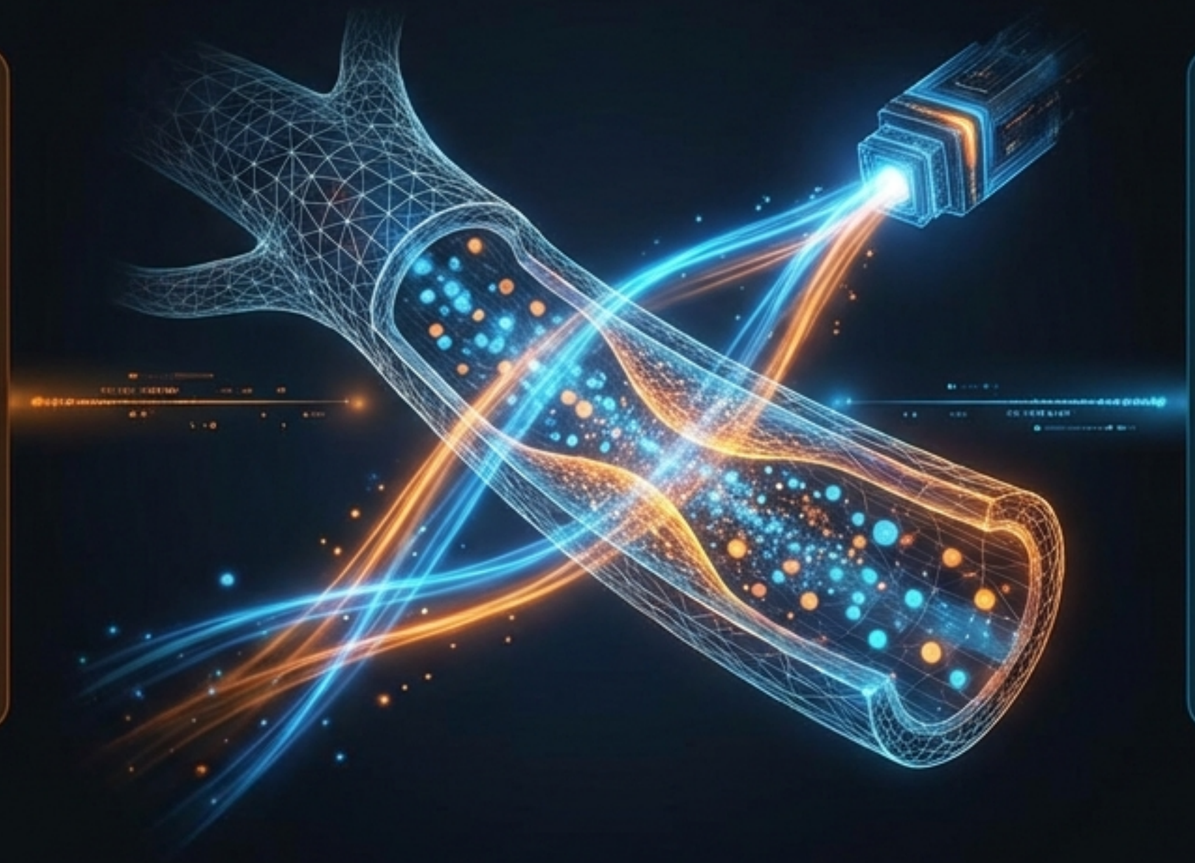
The Future of Imaging

Hardware

Photon-Counting CT (PCCT)

Emerging detector technology with higher resolution. Reduces "blooming" artifacts for precise quantification.



Software

AI-Enabled Quantification

Deep learning analysis (e.g., REVEALPLAQUE) moving beyond simple scores to granular, automated plaque characterization.

Integrating Advanced Hardware and Deep Learning

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Clinical Takeaways

1 Visualization over Probability

CAC transforms risk from statistical guessing to direct disease measurement.

2 Context is King

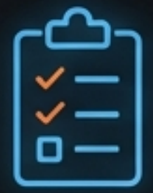
The “Power of Zero” is strong in the asymptomatic, but dangerous in the symptomatic (beware soft plaque).

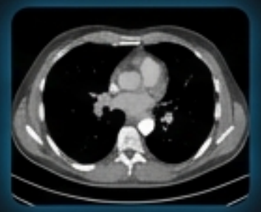
3 The Athletic Paradox

Lifelong endurance athletes may have higher CAC. Treat the risk factors, but acknowledge the fitness benefit.

4 The Right Tool

Use CAC for asymptomatic risk stratification; use CCTA for symptom evaluation.





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