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ACP, Florida Chapter

Tampa, September 7, 2018

Our Team focus :

- **CCTA versus Stress Tests**
- **Vulnerable Plaque versus Plaque Burden**
- **CT-FFR and AI**
- **Sherlock Program :CTA and CT-FFR Applications**
- **Cognification**

The Transformation of Medicine

- Employment of Physicians by Organizations, Stark Law, Value
- Digitalization of Medical Records & HIPAA
- Codification of Diagnosis and Encounters
- RVUs equivalent of billable hours/ Monitoring Productivity
- Management by those with limited medical experience
- Industrialization , M & A, Doctors and Patients as Commodities
- Substitution of Guidelines for Critical Thinking
- Payers Profound Influence and Interference
- Physician Burnout 40%
- Monitization of all Activities, Bundled payment
- Private Equity Purchases , Management , Growth , and Resales
- **Cognification**

Eric E. Harrison MD, FACP
Cardio-Oncology , ICOS
CEO PrivaCors Inc Cardio-Orthopaedics ®
Department of Cardiology,
Professor of Medicine
Morsani School of Medicine,
University of South Florida
Tampa, Florida.
Chief of Medicine,
HCA Memorial Hospital.
eeharrison253@harrisoncardiovascular.com
813-323-5447

Financial Disclosure

- **Vital Images Inc. , Minnetonka, Minn.**

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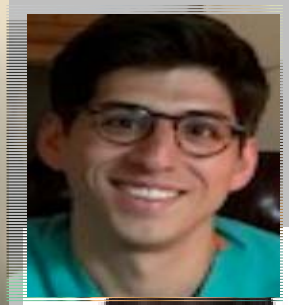
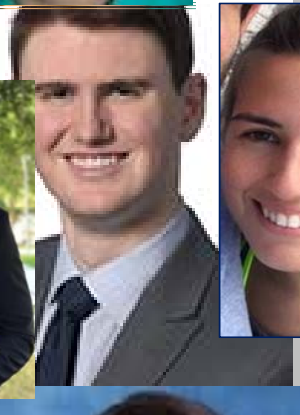
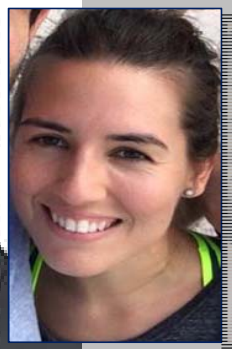
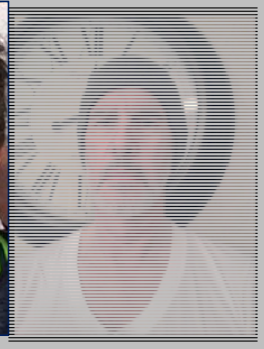
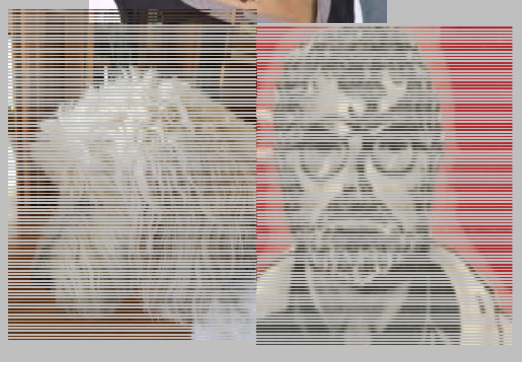
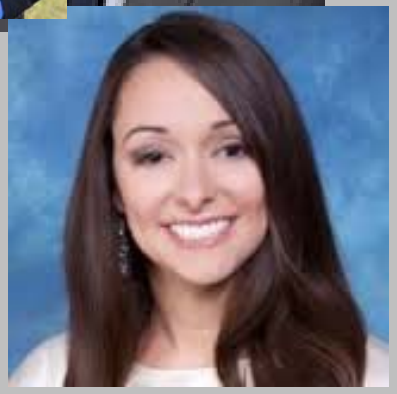




Available/Suggested Techniques for Detection of Vulnerable Plaques

Invasive

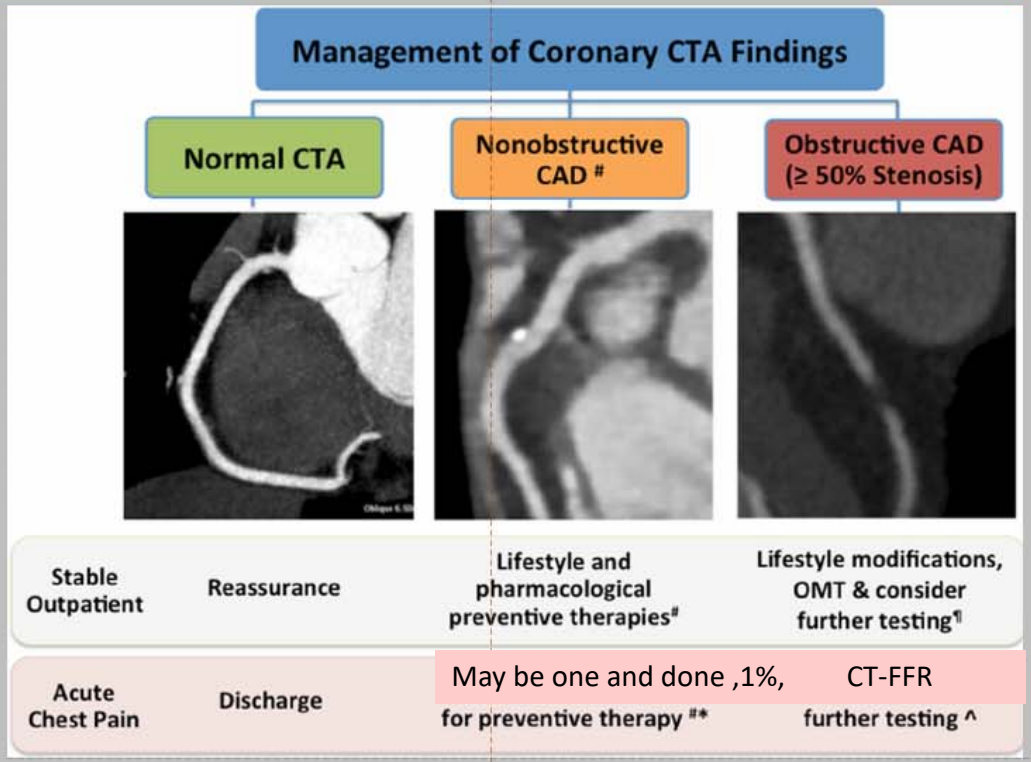
- Angiography
- IVUS
- MRI
- OCT
- Angioscopy
- Spectroscopy
- Thermography
- Elastography

Non-Invasive

- MRA&MRI
- EBCT
- Radioisotope Imaging

CCTA

Personal Patient Coronary Plaque Management



May be one and done ,1%, CT-FFR

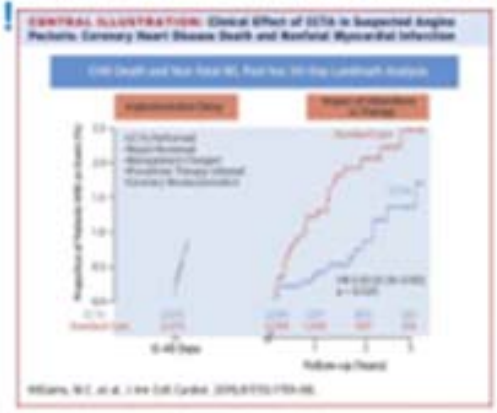
Our Tampa CCTA Milestones

- 2004: Early Adaptor of CCTA
- 2004:Founding Member SCCT, Vital Images Research/Teaching
- 2004:Converted a clinical practice from SPECT/Cath to CCTA, revenue loss $$$$
- 2005: Best selling DVD on CCTA
- 2006: Created our own Cardiac CT/PET/MRI Diagnostic Center
- 2006: USF Cardiac PGY4-6 Training Program
- 2012: Advanced Cardiac Imaging PGY7 Fellow Program
- 2016: Joined IBM Watson Imaging Consortium for AI for CCTA imaging: 1/24
- 2017: HeartFlow Program launched: CT-FFR
- 2018: Working with Enlitic for AI for CCTA Imaging

New Dramatic Change in Testing Results/Outcomes

Scottish Computed Tomography of the HEART Trial

- This is the first time a noninvasive test (CCTA) for CAD
- has demonstrated a benefit (a 50% decrease in rate of fatal and nonfatal MIs) in hard clinical outcomes
- through better targeted investigations and treatments in patients presenting with suspected angina due to CAD compared to standard treatment !



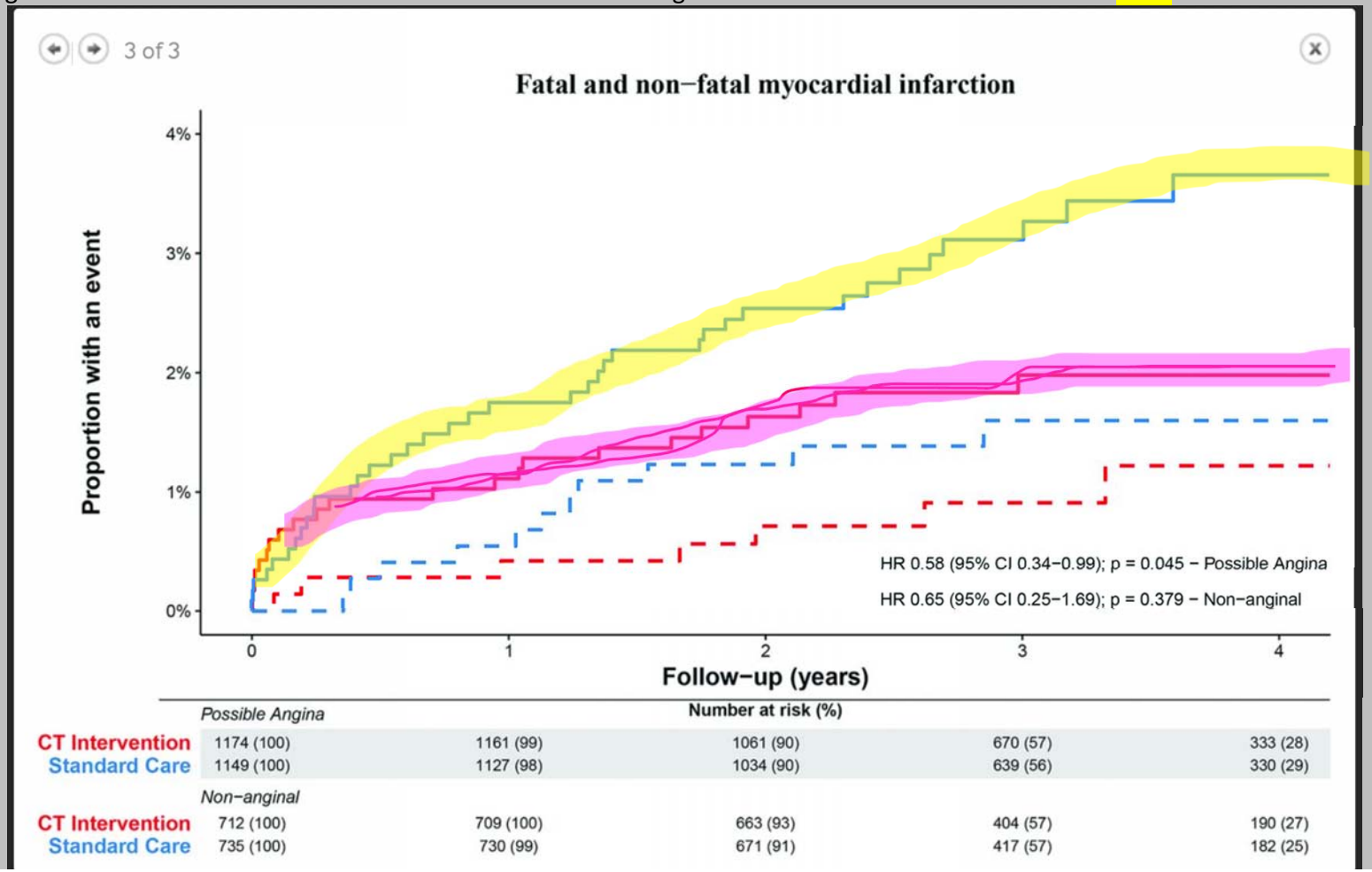
This study results in a significant cost savings and decrease in mortality and morbidity. The glacial response of health insurers to change and improved technology portends an imminent correction .

this is the first time that a noninvasive diagnostic test for coronary heart disease has demonstrated a benefit in hard clinical outcomes through better targeted investigations and treatments in patients presenting with suspected angina pectoris due to coronary heart disease.

- 50% drop in heart attacks with CCTA instead of stress tests

Conclusions NICE-guided patient selection maximises the benefits of CTCA on diagnostic certainty, use of invasive coronary angiography and reductions in fatal and non-fatal myocardial infarction

Diagnostic and prognostic benefits of computed tomography coronary angiography using the 2016 National Institute for Health and Care Excellence guidance within a randomised trial BMJ 2016



Adjustment of System to new information

New European Nice Guidelines For Chest Pain 2016

- 1.3.4.3 Offer **64-slice (or above) CT coronary angiography** if:
- clinical assessment (see recommendation 1.3.3.1) indicates typical or atypical angina or clinical assessment indicates non-anginal chest pain but 12-lead resting ECG has been done and indicates ST-T changes or Q waves. [**new 2016**]

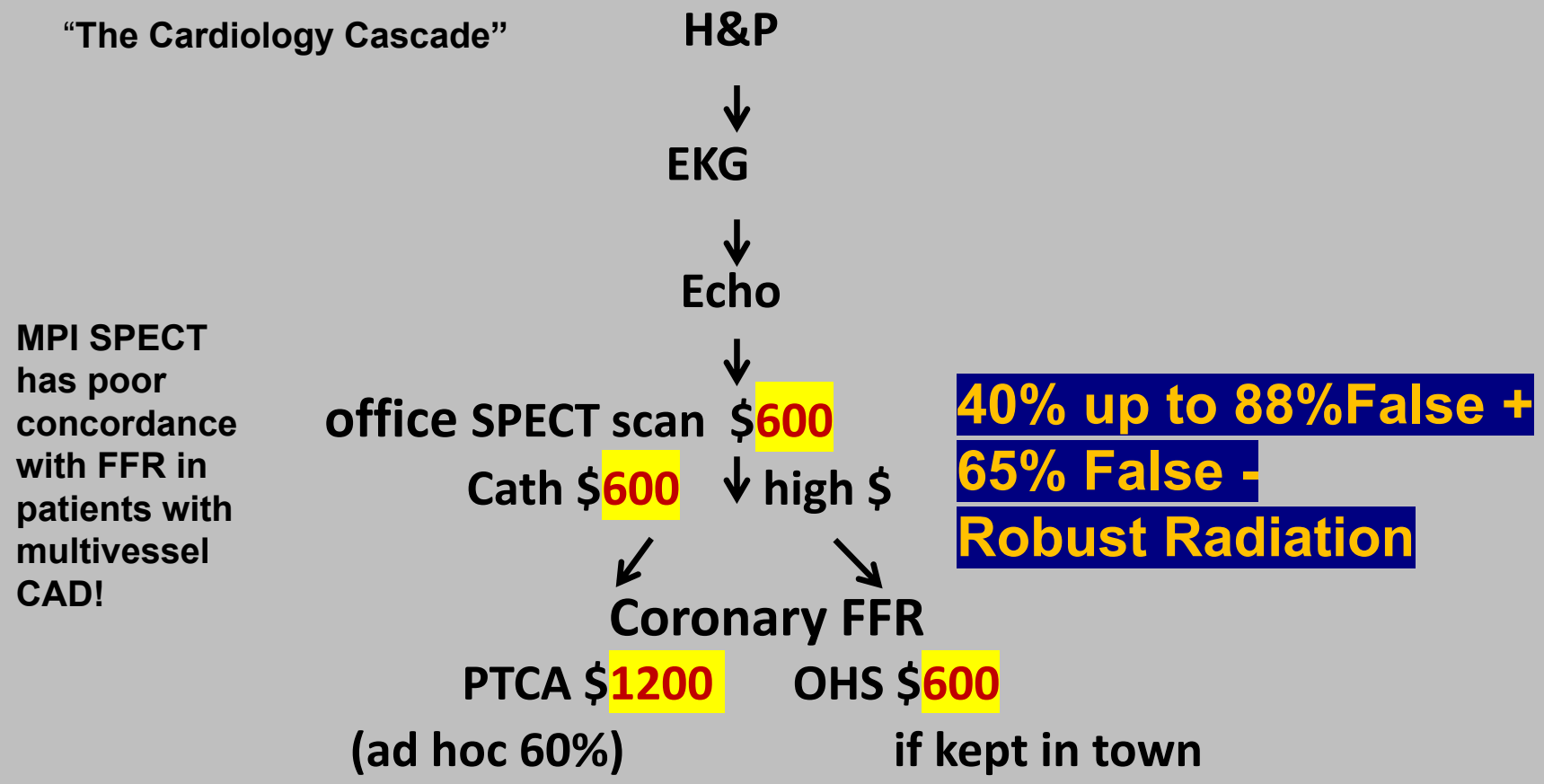
Coronary Computed Tomography Angiography After Stress Testing: Results From a Multicenter, Statewide Registry, ACIC (Advanced Cardiovascular Imaging Consortium)

Table 4. Correlation Between Abnormal Stress Tests, CCTA, and Invasive Angiography

	n	ICA >50% Stenosis	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)	False Positive (%)	False Negative (%)
Abnormal MPI	294	174	64.7	29.4	59.2	34.5	40.8	65.5
Abnormal SE	54	31	40.8	48.9	57.4	32.8	42.6	67.2
Abnormal TMET	40	25	69.4	40.0	62.5	47.6	37.5	52.4
Abnormal stress test, any	388	230	60.4	34.2	59.3	35.2	40.7	64.8

Outpatient Care: Cardiology Cookbook

Cardiologist Financial Incentive



2018 Cardiology Group Analysis Nuclear testing versus CCTA

IPA Nassau Suffolk

Cardiology

29 cardiologists , 5 practices

Nuclear cardiology committed 29,

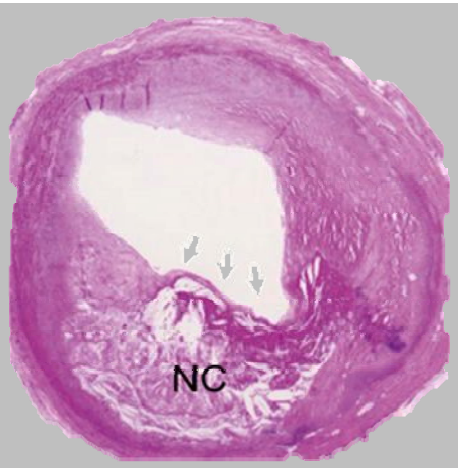
3 SPECT , 1 PET, 1 unknown

Some individual MD CCTA training: 4

What is vulnerable plaque?

The short answer is:

Dangerous forms of atherosclerotic plaques that can rupture or induce thrombosis and lead to critical disruption of blood flow.



Research has shown only 4 characteristics :
Thin cap
Liquid lipid
Larger diameter
Sometimes look like a napkin ring

Only 4 ? This seems too simple

Current Knowledge of Symptomatic Patient Plaques

Motoyama et al: Opus

- 2015 Plaque Characterization by Coronary Computed Tomography Angiography and the Likelihood of Acute Coronary Events 2015 with 2 correlates for high risk plaque : positive remodeling PR (RI=1.1) and low attenuation plaque LAP (< 30 hu). 4423 patients enrolled over avg. of 3.0 years . 45 pts with high risk plaques developed ACS, 43 without with ACS
- 2007 Multislice computed tomographic characteristics of coronary lesions in acute coronary syndromes Correlates were PR and LAP .
- 2009 Computed Tomographic Angiography Characteristics of Atherosclerotic Plaques Subsequently Resulting in Acute Coronary Syndrome

Sherlock Plaque Score: Local Findings

Plaque Parameters: Morphology, Composition, Function, Juxtaposition

- **Activated Platelets Y__ N ___**
- **Convergent –Divergent double cone Angle 1-5 summation of C/D**
- **Plaque Ulcer Depth in mms**
- **Lipid Lake Necrotic Core , “notch” with adventitia base ,% NCS, %NCP, “napkin ring”**
- **% fibrosis . %FS, %FP, Ca in plaque , distal calcium in proximity for reflective wave**
- **Distance from Lumen of NCS mms**
- **% Diameter Stenosis 40%,50%,60%,70%,80%**
- **Stenotic lesion distance from Origin mms**
- **Stenotic lesion distance to end of vessel mms**
- **Amount of Myocardium subtended in gms**
- **HeartFlow CCTA-FFR _____FMM____CCTA-MPI_____**

- **TOTAL_____ Reversibility potential _____ Progression potential_____ Occlusion potential____**

Vulnerable Plaque:

The Paradigm That Failed ? Thought Leaders:

Valentin Fuster, ACC

Peter Libby, Brigham

Steve Nissen, Cleveland Clinic

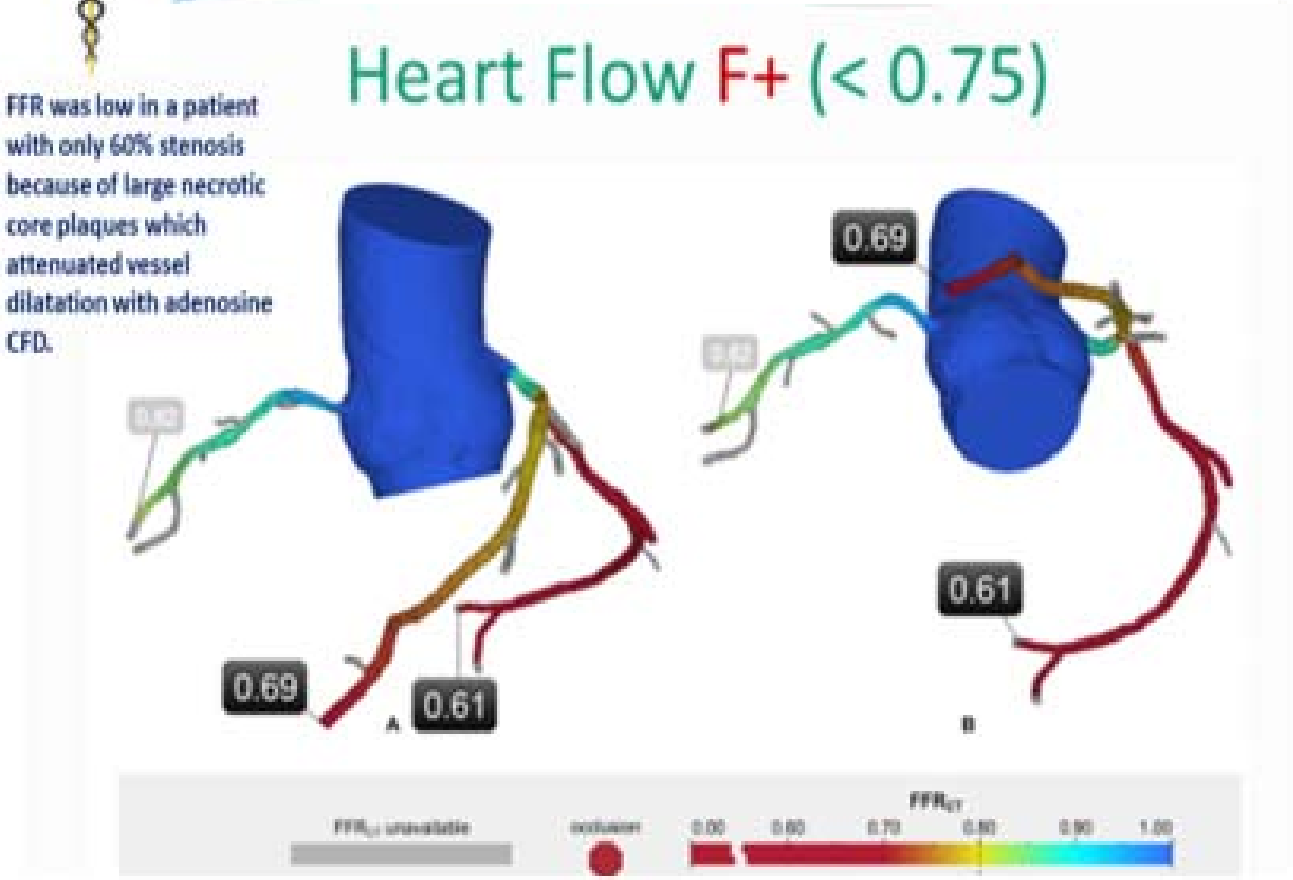
"The Vulnerable Plaque": Transitioning from a Focus on Individual Lesions to Atherosclerotic Disease Burden for Coronary Artery Disease Risk Assessment

Parting Words of wisdom about total plaque burden :

“Many Plaques are vulnerable!

It’s Whaque a Plaque! “

Example of Heart Flow, CT-FFR



Partnering with HeartFlow for FFR access

Artificial Intelligence for the Interpretation of Coronary Computed Tomography Angiography: Can Machine Learning Improve Diagnostic Performance? Daisuke Utsunomiya*, Takeshi Nakaura and Seitaro Oda Diagnostic Radiology, Faculty of Life Sciences, Kumamoto, Japan *Corresponding author: Daisuke Utsunomiya, Diagnostic Radiology, Kumamoto University, 1-1-1, Honjo, Chuo-ku, Kumamoto, Kumamoto, Japan, Tel: 81-96-373-5261; E-mail: utsunomi@kumamoto-u.ac.jp Received date: September 19, 2016; Accepted date: October 17, 2016; Published date: October 25, 2016

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Abstract

Recent development of artificial intelligence (AI) and machine learning system has a potential to improve the clinical diagnosis of coronary artery disease. Coronary computed tomography angiography (CCTA) provides important information of coronary arteries: i.e., stenosis severity, lesion length, plaque attenuation, and degree of calcium deposition. However, the comprehensive analysis of these factors may be difficult. We analyzed patient characteristics and CCTA findings of 56 patients. We used AI (a random forest) to identify the ischemia-related lesions, and compare the diagnostic performance of a random forest and a logistic regression analysis. By the analysis of a random forest, the area under the curve was increased from 0.89 (a logistic regression analysis) to 0.95 (a random forest). Machine learning models can be helpful for the interpretation of CCTA for detecting ischemia-related coronary lesions.

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Our Program

- Our team has curated a coronary computed tomographic angiography(CCTA) cardiac data base since we started Advanced Cardiac Imaging at Memorial Hospital in Tampa, Florida in 2004, 14 years and 5,000 patients ago. This data base with Bayesian inference generates hypotheses to learn to recognize plaque morphology, composition and function to predict heart attacks: the CCTA Sherlock Program. In addition, CT-FFR can be derived from a supercomputer in Palo Alto to measure blood flow in the coronary arteries from the CT scan data sets(HeartFlow®).

Our Program

This process has been shown to give direct value and effectiveness in recognizing vulnerable plaques that can lead to MACE (Major Adverse Cardiac Events). Our team is involved in the application of the CCTA Sherlock program with the Sherlock Plaque Score in addition to echocardiography, limited carotid U/S ,CMR and EKG rhythm recordings creating Tampa Bay Risk Score for evaluating:

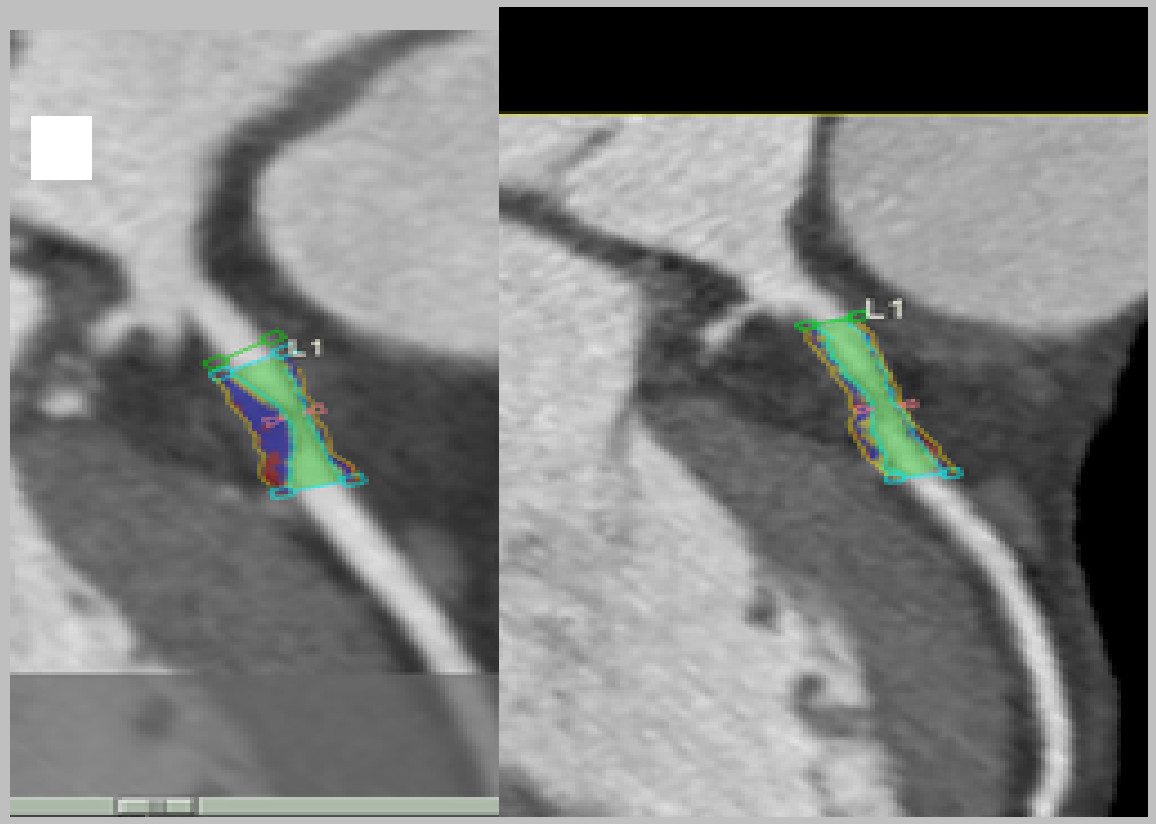
- **Cardio-SOF: Special Operations Soldiers, SOCOM**
- **Cardio-First Responders : Police and Firemen, City of Tarpon Springs**
- **Cardio-Orthopaedics:Preoperative Pelvic floor, Hip, and Knee surgery patients, Cardio-Oncology , Cancer patients , cardiotoxicity, ICOS**
- **Cardio-Concierge, Patients with concierge doctors ,**
- **Cardio-RISK, People with multiple risk factors**
- **Cardio-CAD, People with CP or known CAD**

LAD Plaque progression proximal to stent:20 mos.

LAD Plaque progression proximal to stent:20 mos.

Protocol
Plaque
Regression

BerRoc 2015-2017
66%-44% low carbs, test,PCSK9

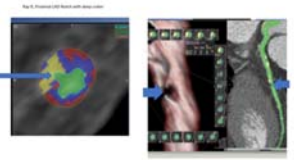


Hypothesis

Plaque: Transcomposition/Morphology/Functionality to Occlusion

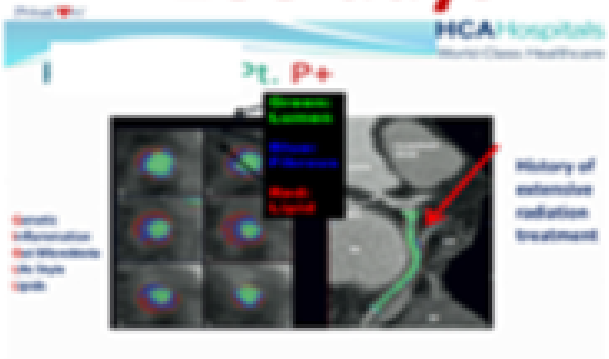
24 hours

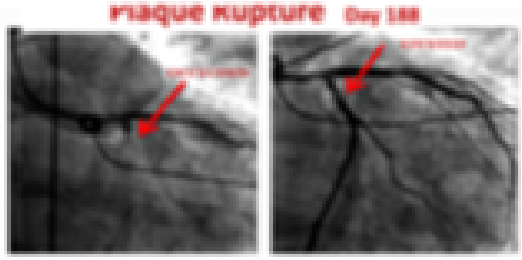
ue(One Day Post Hip Surgery nonSTEMI)



4 days

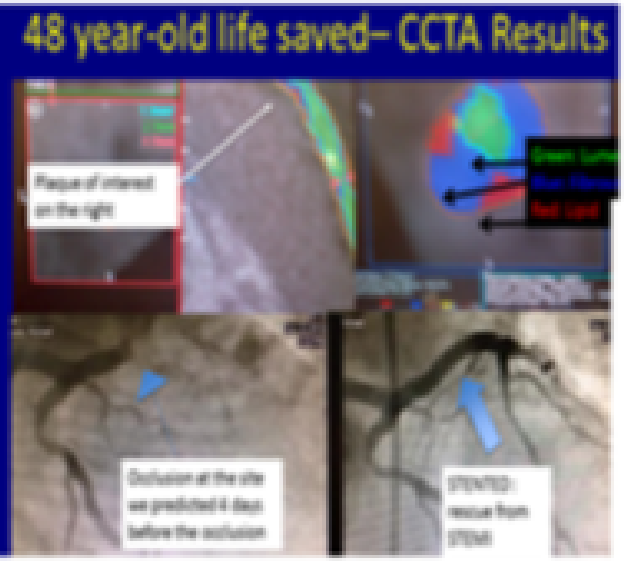
188 days





420 days

>700 days



sition: Hershey's Kiss Plaque NC

Early Reticulated NC

Herheys Kiss Plaque NC

Left to Right Plaque Transcomposition/Morphology/Functionality Equation (TMF)

Observations, Risk, and Objectives

Putting the Program into Action And Gathering More Data!

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Patients on statins were older (mean age 58 vs. 54.7 years; p = 0.001) and had a higher mean number of risk factors (1.9 vs. 1.4, p = 0.001), **yet were less likely to have any high risk plaques (13.3% vs. 31.3%;** p = 0.003), despite similar numbers of obstructive and nonobstructive CAD. -ROMICAT

DANGER ZONE

Malignant Coronary Calcinosis

Benign Coronary calcinosis

Safety Zone

Long Term Prognosis!

Decades : 30 s → 40s → mid 40s → 50 → → → 60s → 70s → 80s

CONFIDENTIAL

Left to Right Plaque Transcomposition/Morphology/Functionality Equation (TMF)

Observations, Risk, and Objectives

The Tampa Group

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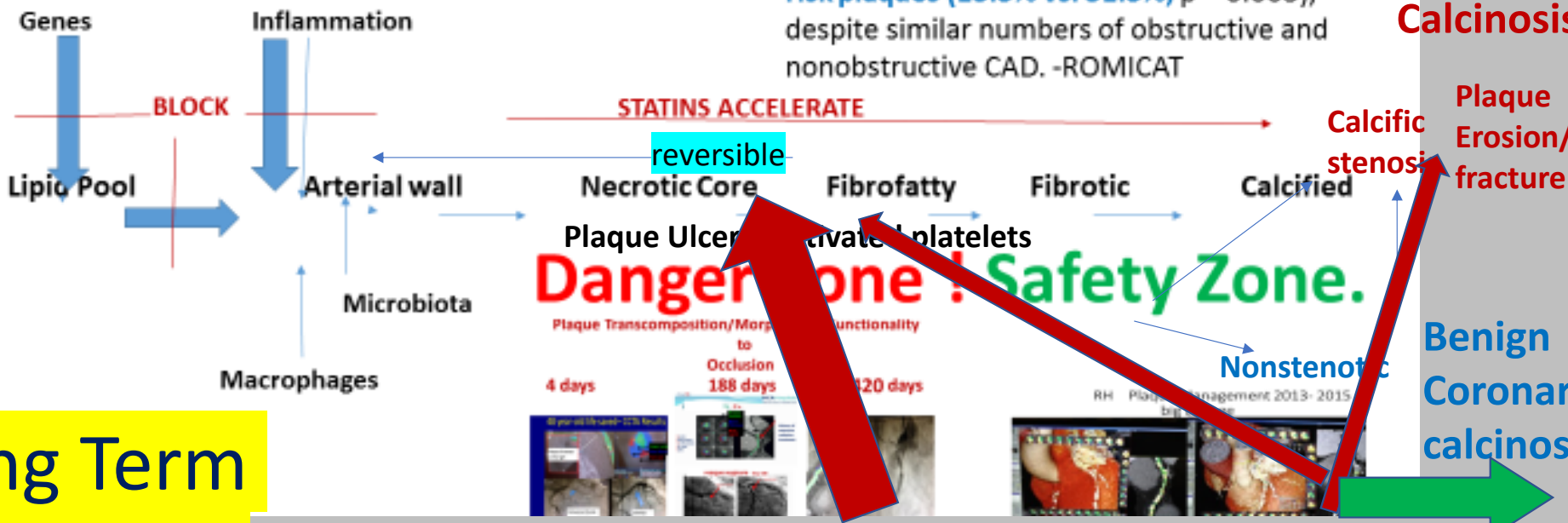
Patients on statins were older (mean age 58 vs. 54.7 years; p = 0.001) and had a higher mean number of risk factors (1.9 vs. 1.4, p = 0.001), **yet were less likely to have any high risk plaques (13.3% vs. 31.3%;** p = 0.003), despite similar numbers of obstructive and nonobstructive CAD. -ROMICAT



DANGER ZONE

Malignant Coronary Calcinosis

Benign Coronary calcinosis

Long Term Prognosis!

Decades : 30 s → 40s → mid 40s → 50 → → → 60s → 70s → 80s

Safety Zone

CONFIDENTIAL

Long Term Prognosis

COR-RADS Reporting and Data System

- CAD-RADS 0 0% no CAD
- CAD-RADS 1 1-24% minimal non-obstructive CAD
- CAD-RADS 2 25-49% mild stenosis
- CAD-RADS 3 50-69% moderate stenosi
- CAD-RADS 4 70-99% severe stenosis
- CAD-RADS 5 100% total occlusion
- CAD-RADS N Non-diagnostic : further evaluation?
- / separates two or three modifiers
- Modifiers : S = stent , G = graft , V = vulnerability JCCT 10 (2016) 269-281

1)15 years, zero events

2)Less than 1% per year risk

3)If totally calcified, low risk

Risk of these depends on LV, and whether vulnerable plaque is present .or calcific plaque is obstructive or erosive

Definition of significant coronary artery disease

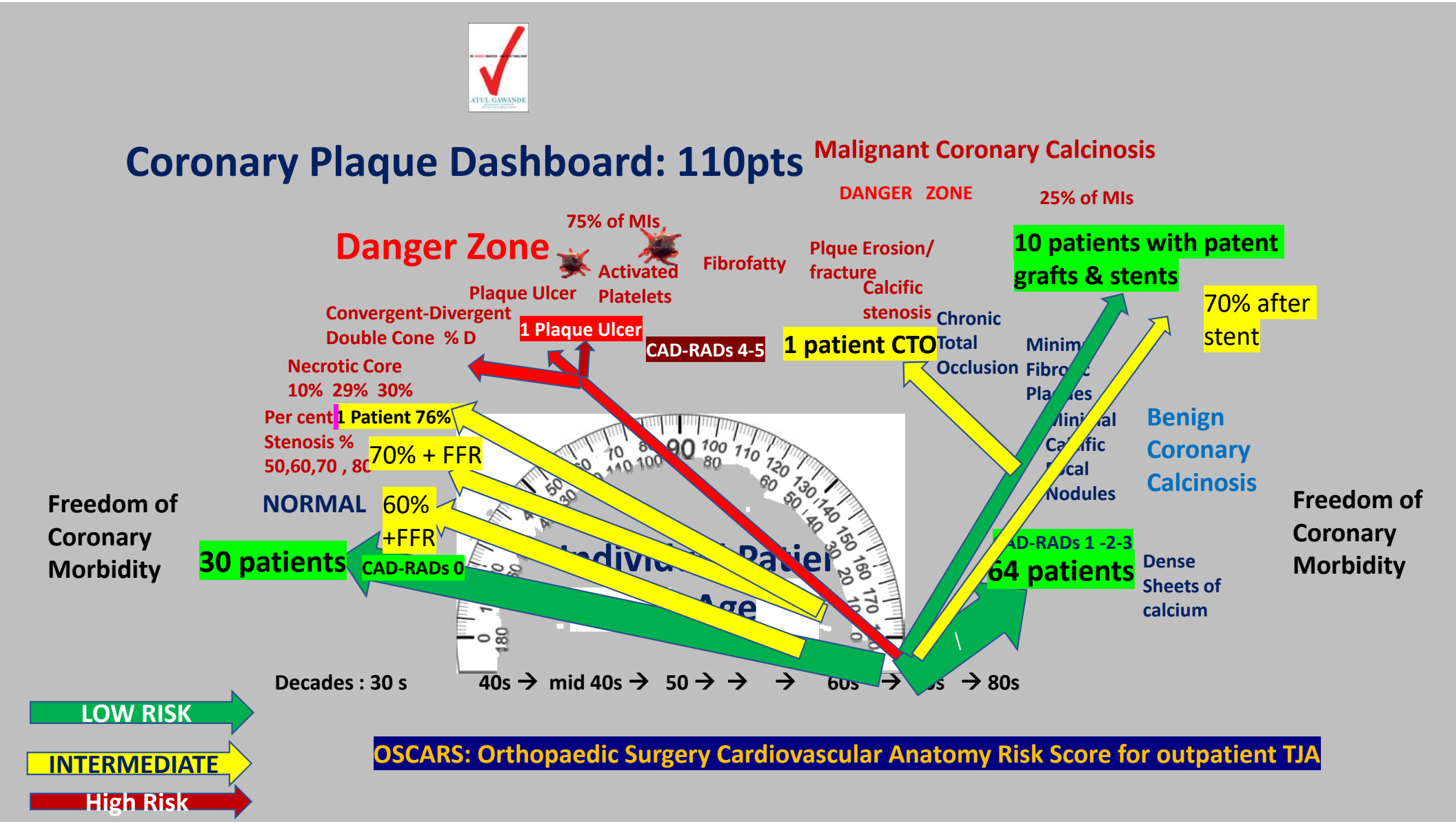
F= FFR by Vessel Name

Significant coronary artery disease (CAD) found during CT coronary angiography is ≥ 70% diameter stenosis of at least one major epicardial artery segment or ≥ 50%

Applications / Cognification Plans

- Cardio-Orthopaedics
- Patient with + FH and low Ca Score
- Calcium Score Examples over time and theory
- An asymptomatic Cardio-Orthopaedic Patient
- An Asymptomatic SOF Patient

Coronary Plaque Dashboard: 110pts



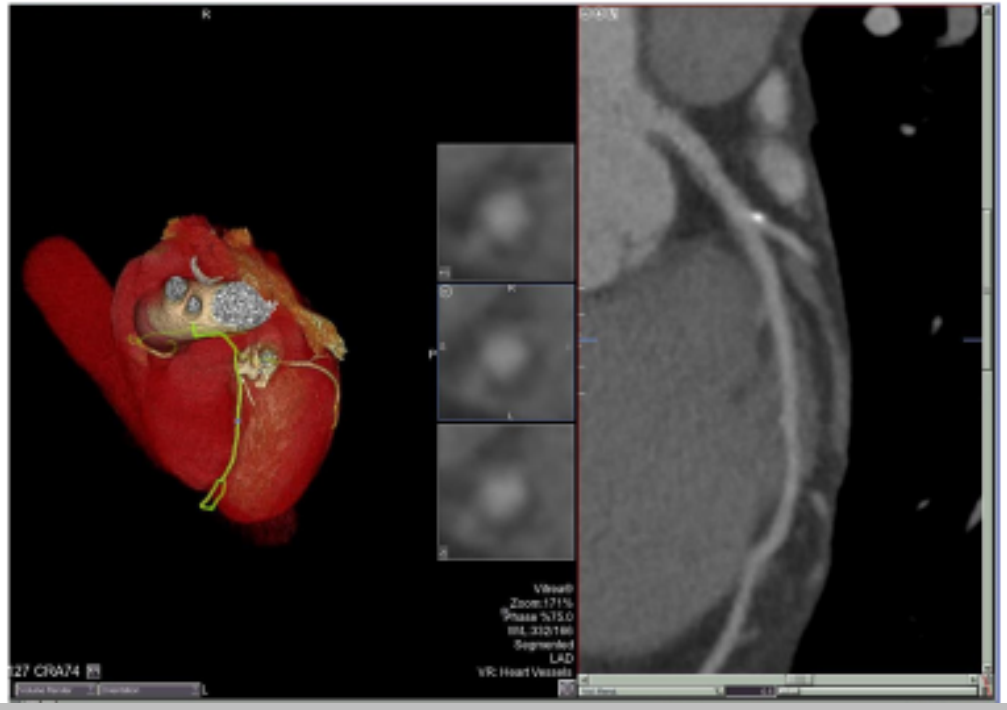
Patient: AL

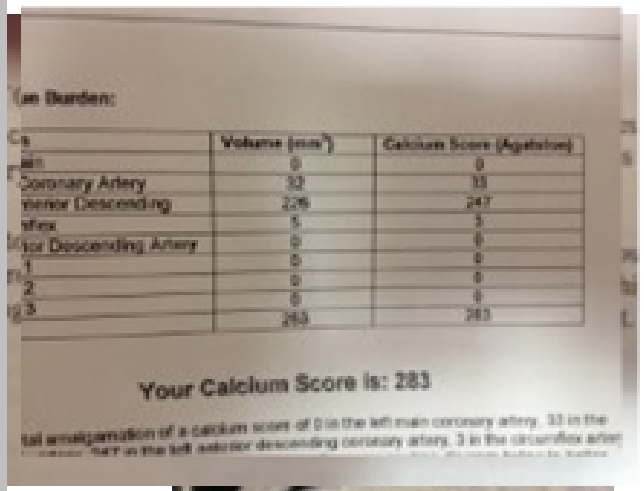
Prognosis

- **Calcium Score 33**
- **Minimal Nonocclusive calcified LAD and RCA Plaque**
- **Calcium Score may stay the same (one and Done) or gradually increase by ossification**
- **Continue Current Rx and Life Style**
- **No compelling need to repeat study in the future.**

Patient with Ca2 of 5 and single calcified plaque 12 years ago. Current Assessment

"**One and Done"**





"An increasing body of evidence suggests that greater calcium density in plaques is associated with decreased CVD risk,"

(JAMA, January 15, 2014, Vol. 311:3, pp. 271-278).

Calcium score increases over 11 years : 283 to 625

Two Patho-etiologies of Progressive Coronary Calcification

- **1) Transcompositional coronary calcification** → stenosis / nonstenotic
- necrotic core → fibrofatty → fibrous → calcification
- **2) Ossification Plaque Growth** → Usually nonstenotic
- Calcium begats calcium
- Hydroxyapatite added to pre-existing calcified plaque whether visible on CT or sub CT resolution

CASE 1

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How can we change this and prevent myocardial infarction and AF?

Example: Patient with risk of both!

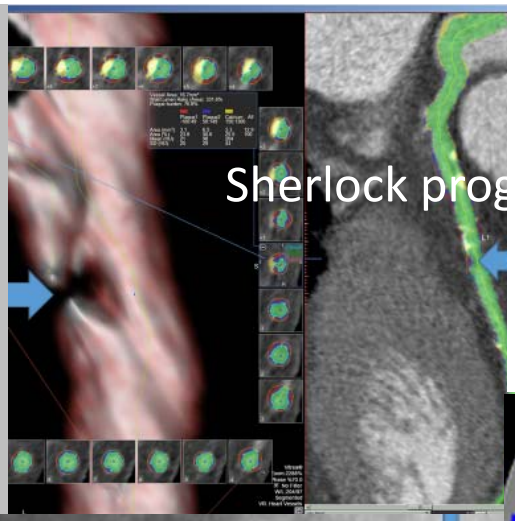
- 68 y/o CMM
- remote history of AF 12 years ago and recent recurrence in Sept , AF with HR 84 when preop evaluation for endoscopy.
- No Known Coronary Artery Disease
- Normal EKG and Echo
- Low Risk for Hip Replacement

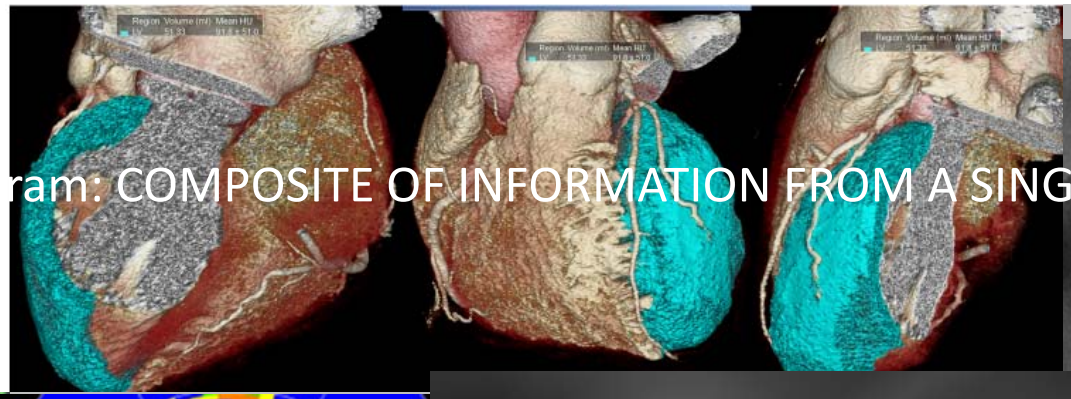
Outdated Risk Score based on age and cardiac history which are nonmodifiable .

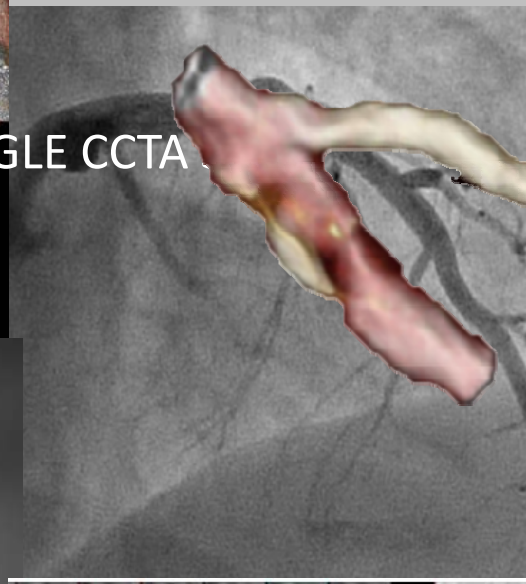
1994 CHARLSON RISK SCORE 2

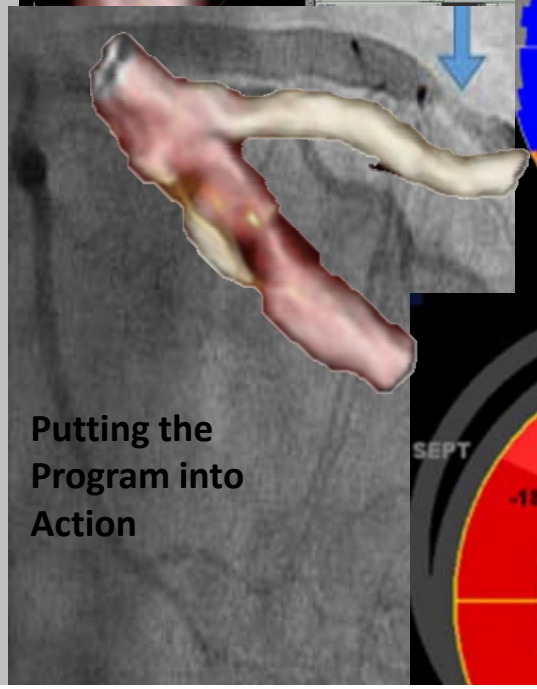
But he has episodes of atrial fibrillation and could have hidden CAD. Are we underestimating his risk of hip surgery by age and history alone as nonmodifiable risk factors? Why do we do this?

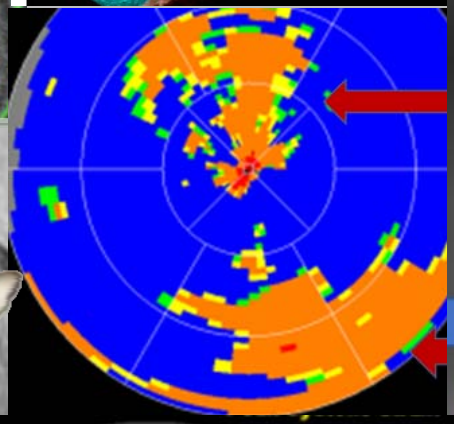
Sherlock program: COMPOSITE OF INFORMATION FROM A SINGLE CCTA

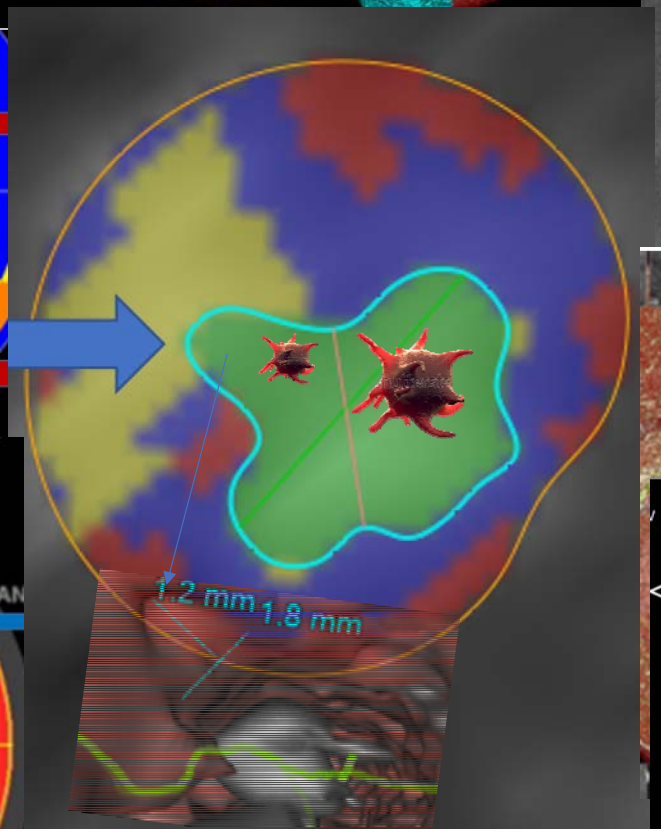


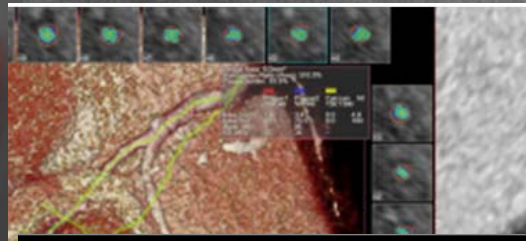


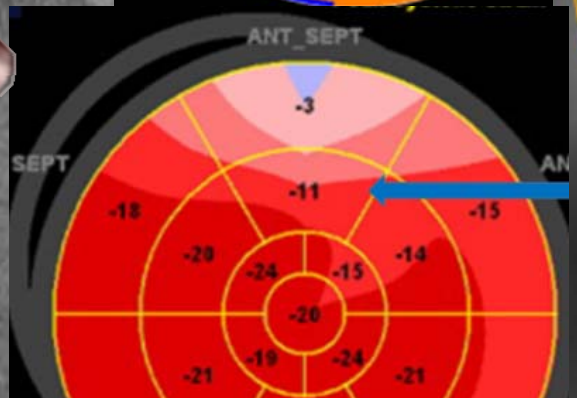


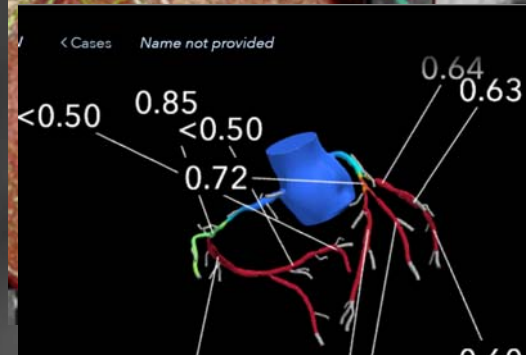












Putting the Program into Action

[redacted]

Coronary Plaque Dashboard

Malignant Coronary Calcinosis

DANGER ZONE

25% of MIs

75% of MIs

Danger Zone

Plaque Ulcer 1-5

Convergent-Divergent Double Cone

Angles : 1,2,3,4.5

Lipid Lake:
Necrotic Core

1,2,3,4,5

40, 45, 50, 55, 60, 65,

NORMAL

Activated Platelets

Fibrofatty

Calcific stenosis

Main Left Stenosis

Plque Erosion/ fracture

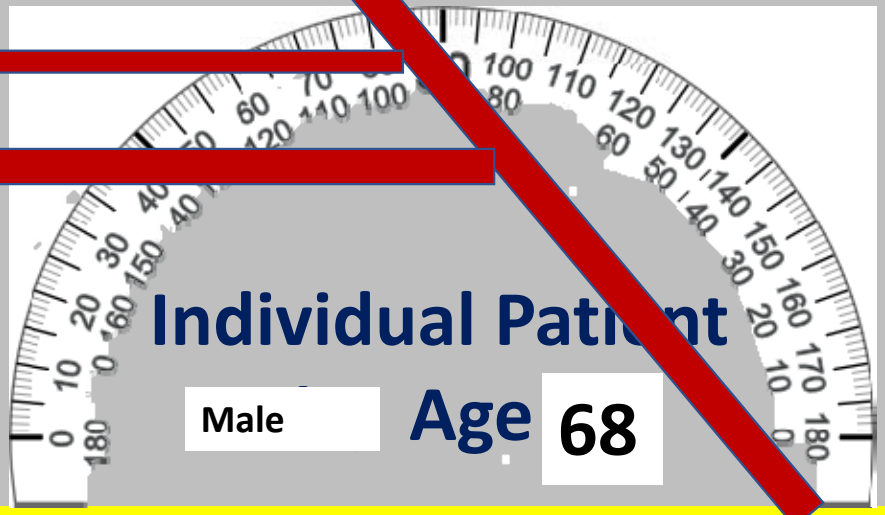
Chronic Total Occlusion

Minimal Fibrotic Plaques

Minimal Calcific Focal Nodules

Dense Sheets of calcium

Benign Coronary Calcinosis



Individual Patient

Male

Age 68

Decades : 30 s 40s → mid 40s → 50 → → → 60s → 70s → 80s

Sherlock Plaque Score

Actions Taken based on plaque MCF (Sherlock Score)

- **Called chief of orthopedics of FOI/TGH who was going to replace the hip.**
- **Change hospitals and surgeon so my RN navigator can watch patient for a heart attack.**
- **Plan: Prevent PAF with ranolazine/dronedarone pre, op,& post.**
- **Medicare won't cover a stent ;patient was told he would have an heart attack and would be rescued, surgery on Friday**
- **Navigator followed patient and discharged him home with daughter who had Nurse Navigator's cell phone number. D/C ed home Sat.**
- **Patient developed Chest Pain during lunch within an hour of arriving home and called and was told to come back to the hospital. Returned to Hospital. Sat.**

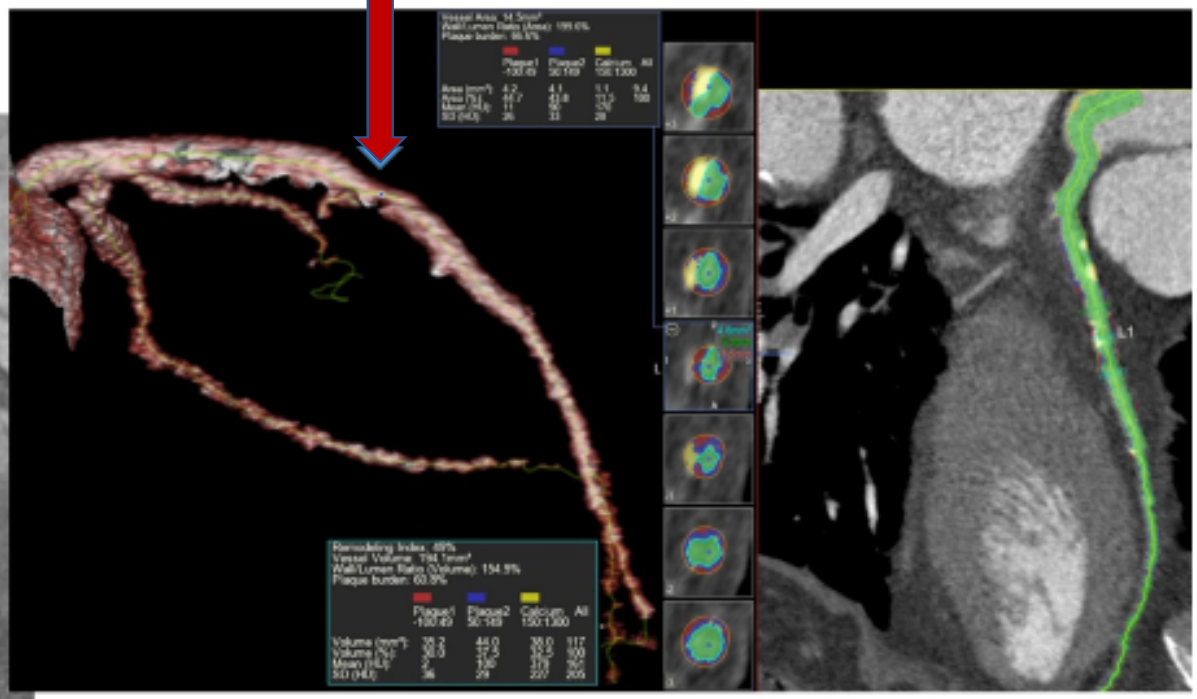
Acute Coronary Insufficiency with severe CP after hip surgery and stopping Eliquis: PTCA/Stent of LAD

CATH

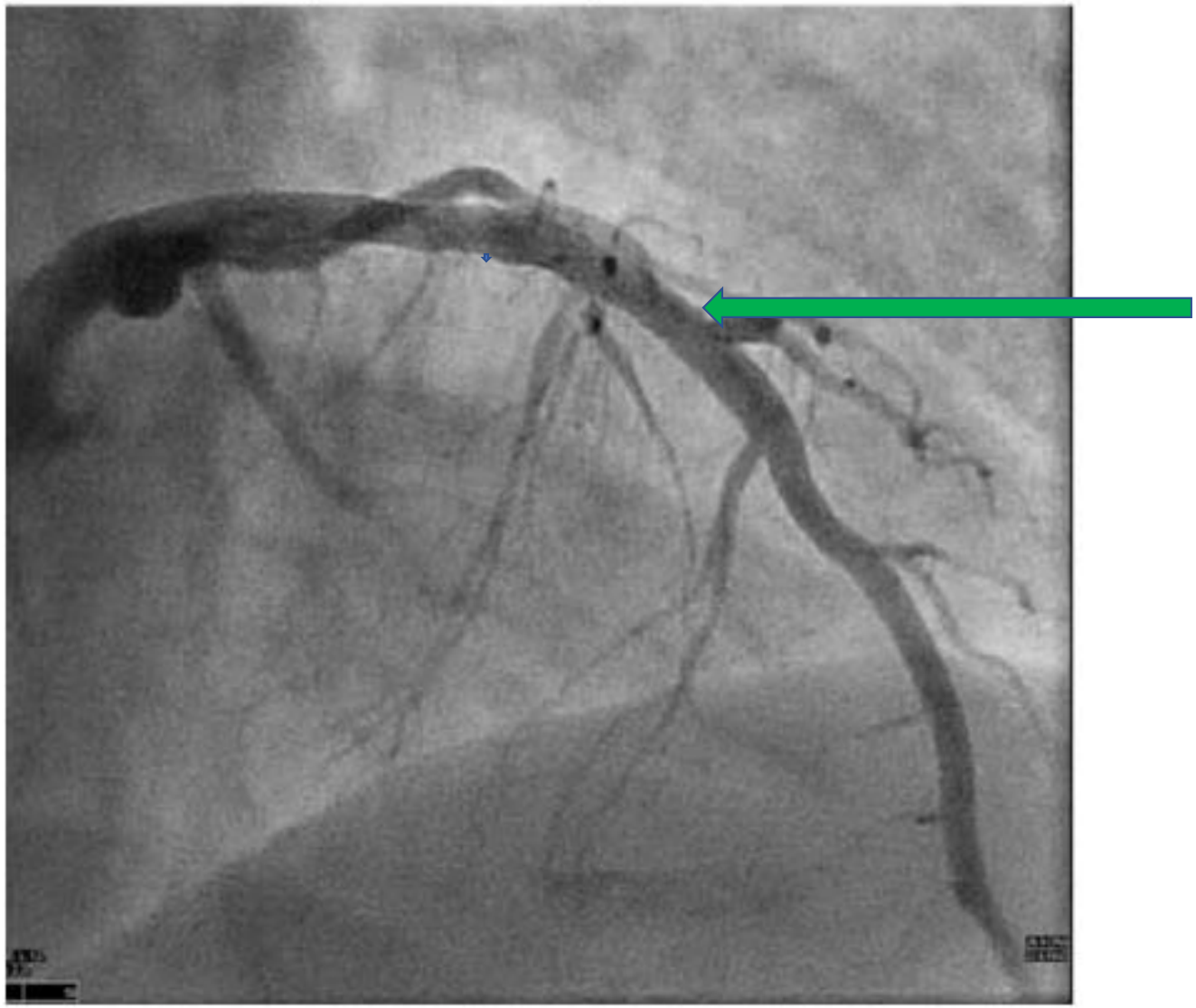
CCTA

Random probability of predicting an Mi on any one day post op hip is >1/10,000

Plaque Ulcer + Activated Platelets?? = Heart Attack

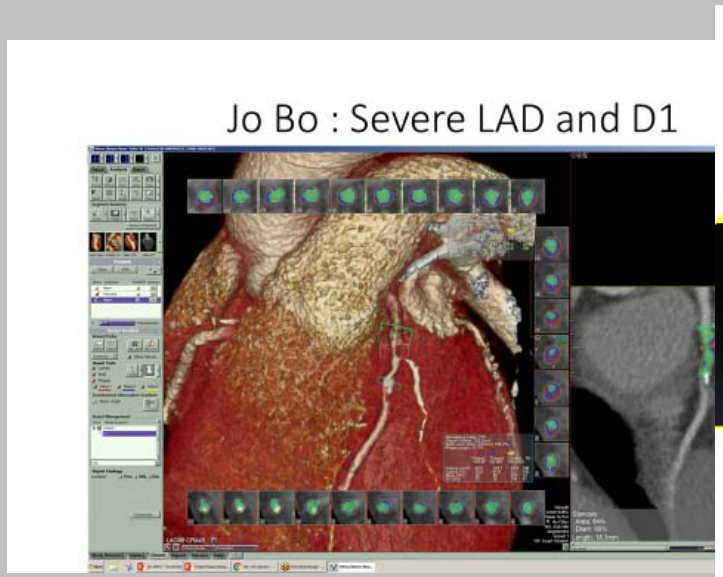


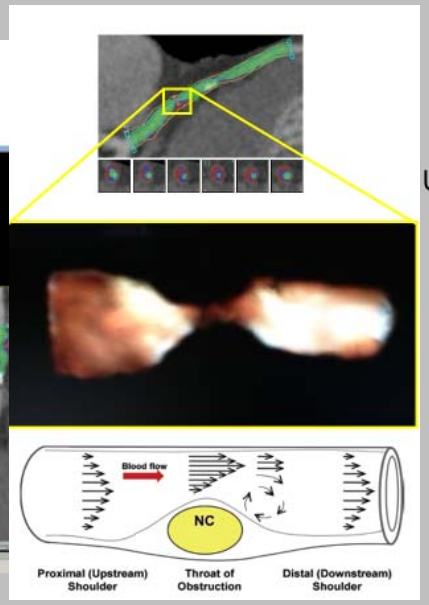
Ray RA LAD: Stents in proximal LAD



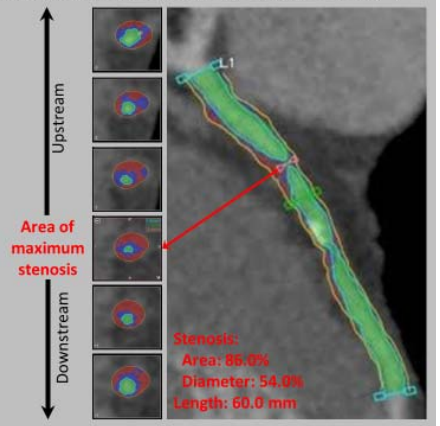
I'm very happy that I had my hip surgery and also grateful that Dr. Harrison and **Sharon** prevented me from getting atrial fibrillation but also knew I would get a heart attack which they anticipated and prevented damage to my heart and hip.

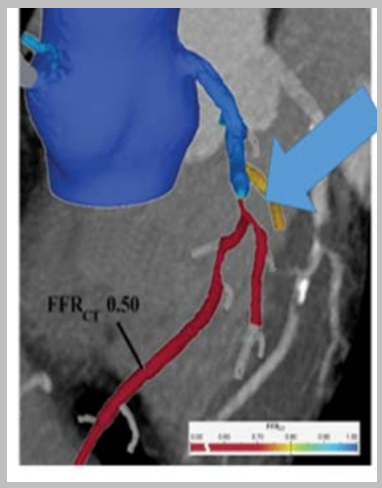
48 y/o asymptomatic SOF whose father had a heart attack at age 44.





ue characterization on CCTA

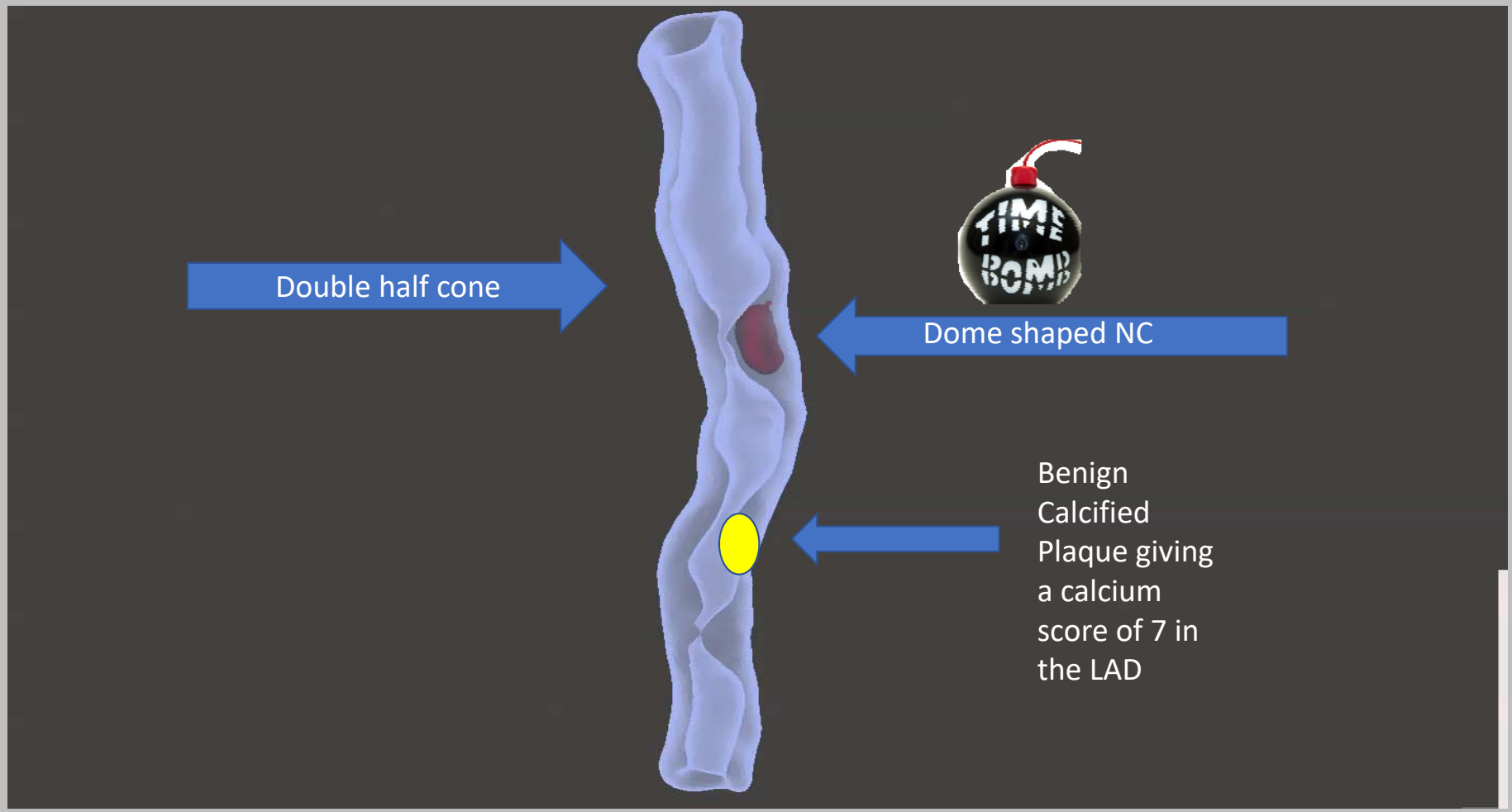




"You are going to have a heart attack next week and we've got to do something to prevent it ! "

Hypothesis

LL + CDDC = ACS

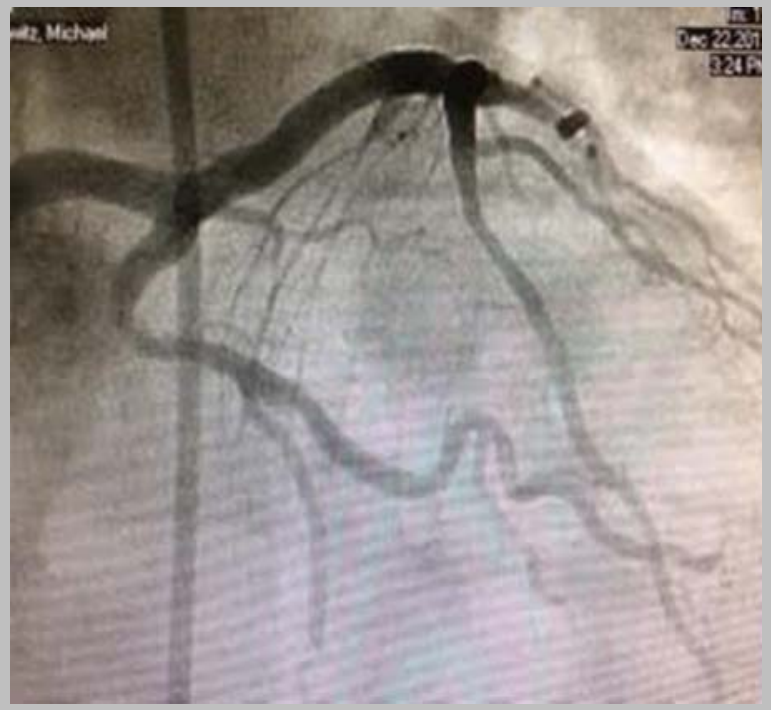


4 days later…

- Patient began having left clavicular(prior fractured during parachute jump) discomfort while playing a video game, similar to before, 30 min duration, burning in quality with sweating. Wife noted change in color, Patient had not initiated his recommended medical therapy. He shrugged off his discomfort, but his wife recalled the CTA plaque demonstration online during husband's visit, and called EMS for further evaluation.

PCI

Before



After

SOF Survivor

Classified :
This never happened

WorkFlow, Hospital Network

- My associate, our 4th year fellow and I read Echos, CCTAs , CMRs daily .
- My team and I spend about 15 mins per study teaching CCTAs to our fellow.
- It is possible to read a study every 5 mins but this requires a lot of pointing and clicking with the mouse to get through a study
- The workflow is very active. For 12 per hour , **100** = **x per day**. I need to accelerate this by a factor of **10 x** for one division of 15 hospitals and for 20 divisions accelerate by **200 x**!

What do we do?

- How to go from **n=100** to **n=1000** ?
  - Example of Successful Models :
    - Numerical Computer Interpretation of EKGs.
    - HeartFlow FFR Numerical Supercomputer use.

- Our model with **Deep Learning Supercomputer:**
  - personal plaque analysis prognosis with learning through a cognitive computed prognostic data base
  - FFR equivalent calculation,
  - Medicare billing code for heartFlow's cardiac CT FFR coronary artery disease numerical supercomputer calculated blood flow Increased efficiency and productivity with cost saving, decreased LOS
  - Reference Images
  - Evidence based current bibliography

How to get to 100x ?

20,000 CCTAs/daily

Pattern Recognition

- 1)Partner with **IBM Watson Healthcare** for cognitive computing for pattern recognition and storage. Join their ecosystem of corporate partners & software developers
- **2)Study the workflow** to reduce clicks and automate
- 3)Share all images with Watson data base in our network as well as others
- 4)Assign coordinates to all arterial segments automatically with software for loci fixing and site comparison (**address**)
- 5)Every plaque can be reduced to a string of numbers with an “address”
- 6)Export all data into a report automatically
- 7)Use Universal Reporting System nomenclature CAD-RADS 1-6 /v/s/g
- 8)Use hospital sites for alpha development beta testing.

New Partner: Enlitic

Our Mission

Every time a doctor sees a patient, they are solving a complex data problem. The goal of each case is to arrive at an optimal treatment decision based on many forms of clinical information, such as the patient's history, symptoms, lab tests, and medical images. The quality and quantity of this data is rapidly improving—it's estimated to grow over 50-fold this decade, to 25,000 petabytes worldwide by 2020. Our world-class team of medical professionals and data scientists has made it our mission to improve patient outcomes by using this data to its maximum potential.

Enlitic uses deep learning to distill actionable insights from billions of clinical cases. We build solutions to help doctors leverage the collective intelligence of the medical community.

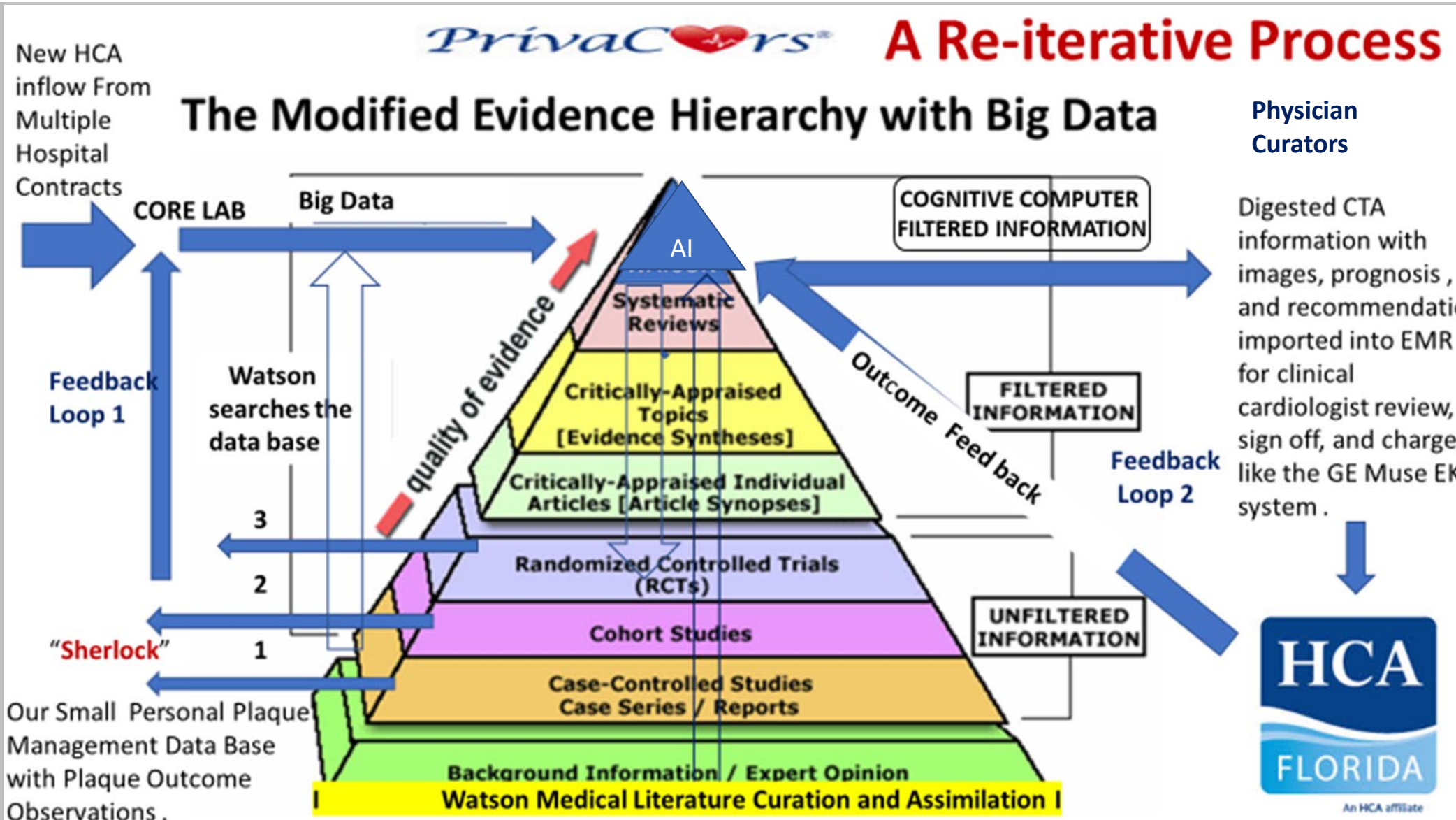
The Coronary AI ReCoLab

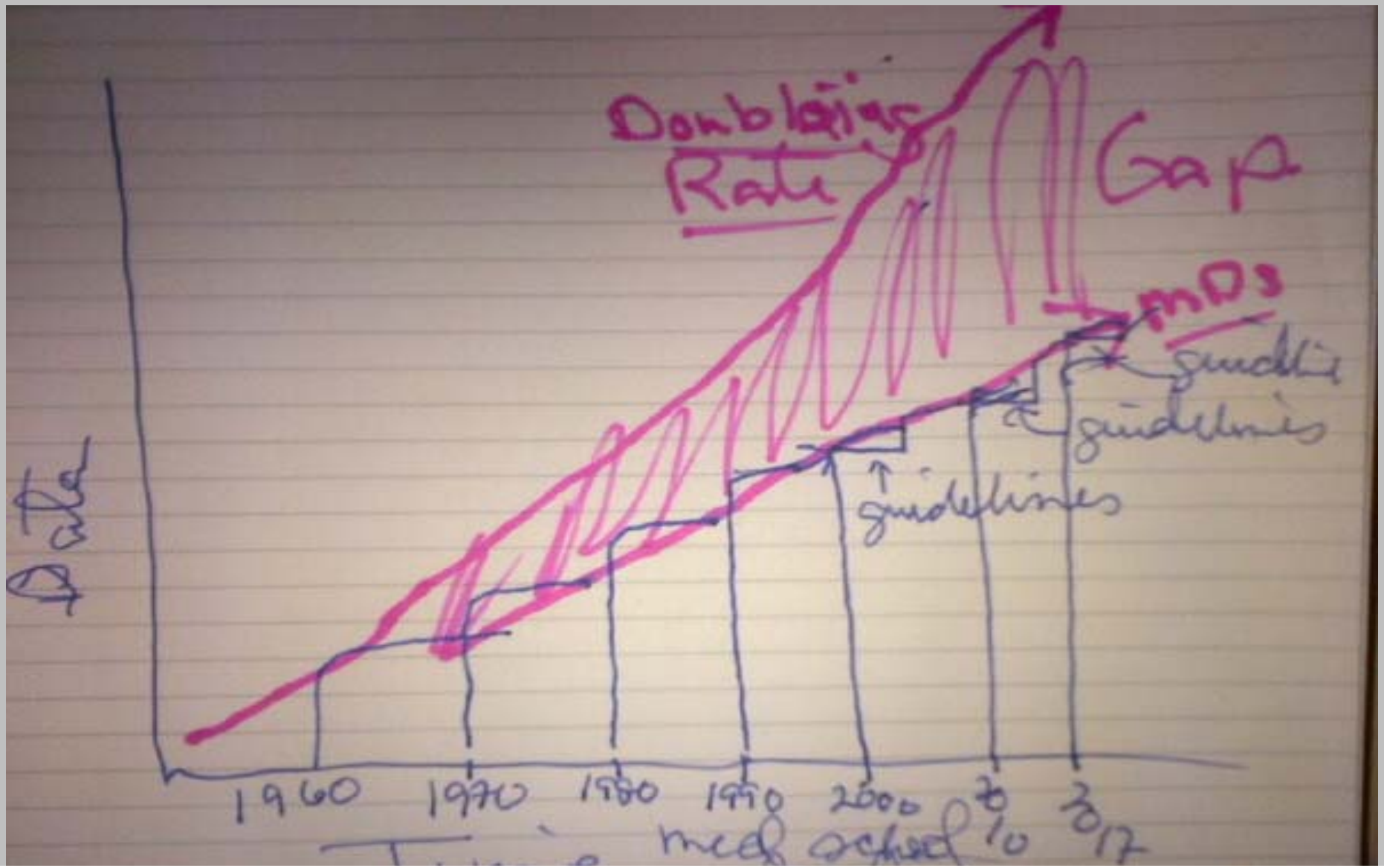
Our mission is to improve personal patient cardiovascular health by co-developing and co-evaluating new artificial intelligence technology for cardiac imaging.

PrivaCors

A Re-iterative Process

The Modified Evidence Hierarchy with Big Data




Doubling Rate
Gap
MDG
guidelines
guidelines
Data
1960
1970
1980
1990
2000
2010
2017

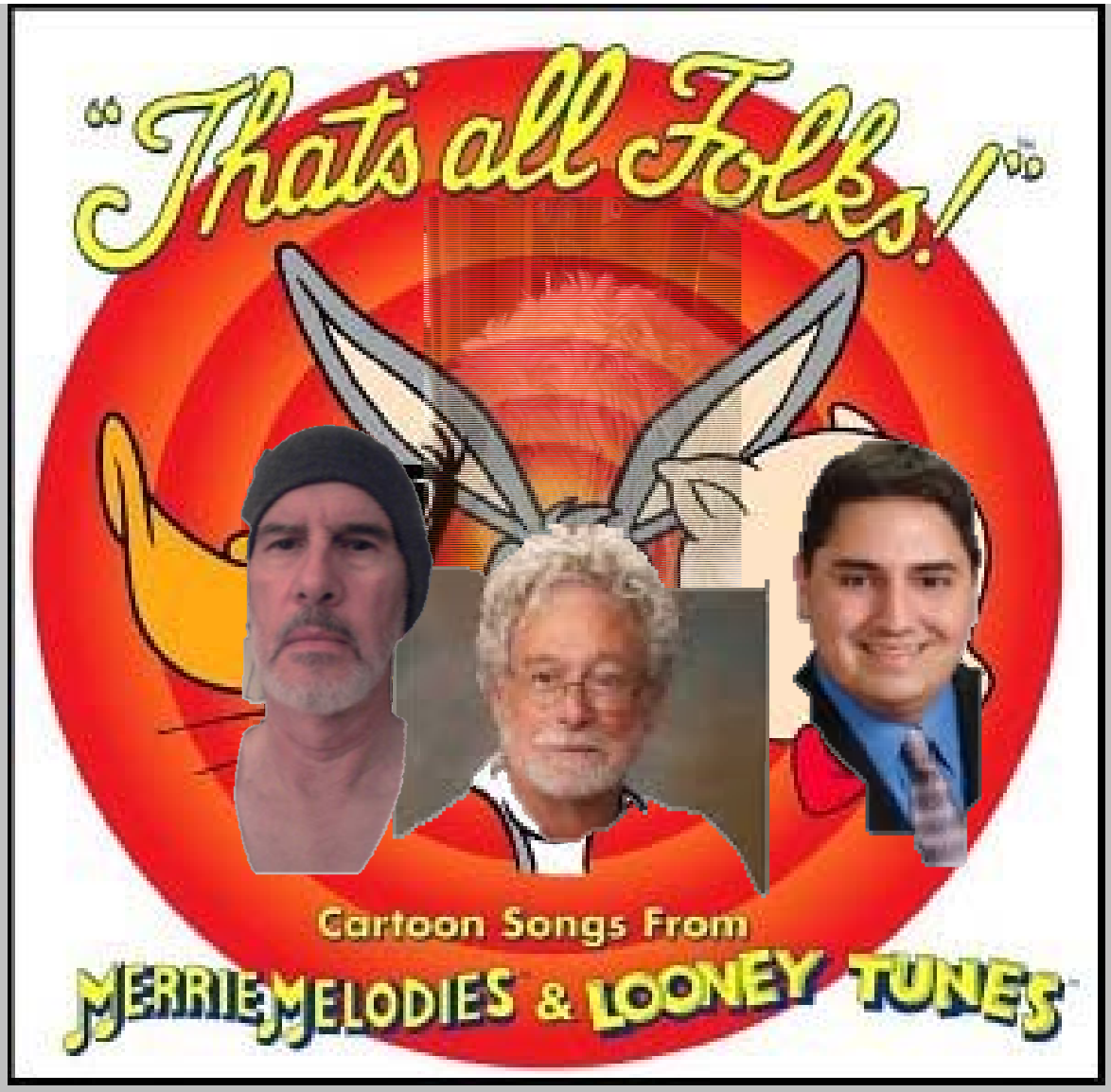
MOC question

The Scottish Study Compared outcomes of patients suspected of having angina pectoris randomly assigned to stress testing modalities versus CCTA.
The outcome of this study demonstrated :

1) **Patients receiving stress tests had 50% less heart attacks and mortality.**
2) **Patients receiving CCTAs had 50% less heart attacks and mortality.**
3) **There was no difference between the two groups.**
4) **Stress tests resulted in better targeted investigations and treatment.**

Answer : 2) Patients receiving CCTAs had 50% less heart attacks and mortality . This was because of the findings resulted in better targeted investigations and treatments

CT coronary angiography in patients with suspected angina due to coronary heart disease (SCOT-HEART): an open-label, parallel-group, multicentre trial
The SCOT-HEART investigators[††]Members listed at end of report
Published: 15 March 2015, Lancet , Volume 385, No. 9985, p2383–2391, 13 June 2015


"That's all Folks!"
Cartoon Songs From
MERRIE MELODIES & LOONEY TUNES