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CORONARY ARTERY CALCIUM SCANNING
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Every study of CAC has demonstrated its superiority OVER Risk Factor-Based Paradigms (Framingham Risk Score).

- The data **clearly** demonstrates an increasingly worse prognosis with increasing CAC on serial scans.
- CAC is **strongly** associated with the development of stroke and congestive heart failure.

A quote from Arthur Schopenhauer “All truth passes through three stages: first it is ridiculed; secondly, it is violently opposed and thirdly, it is accepted as self-evident.”

Coronary Artery Calcium Scanning (CAC)

It is a tool for risk assessment in the asymptomatic population and has been the subject of over 2500 papers in peer reviewed literature.

- It is still controversial
- Not in all the guidelines for risk assessment
- Insurance coverage is non-existent
    - Perhaps it is cheaper to call it investigational
        - The penetration into clinical practice is low

Coronary Artery Disease accounts for more deaths than all cancer deaths combined.

The CAC Scan

- Non contrast
- Limited study
- CT Scan with 3-5 second breath hold
- Coronary artery calcification is quantified through the entire epicardial system (this is the area in which all of the major coronary arteries are located on the surface of the heart)

- The score is determined by multiplying the calcified plaque area by the maximal calcium lesion density, which is scored 1-4.
- Scores:
    - 0-absence of calcified plaque
    - 1-10 Minimal calcified plaque
    - 11-100 Mild calcified plaque
    - 101-400 Moderate calcified plaque
    - Over 400 is severe calcified plaque
- The radiation exposure associated with CAC is similar to that associated with mammography

Percentile Scores

- These are generated by comparing the subject's calcium score with that of others of the same sex, age, and ethnicity through the use of large databases of asymptomatic subjects.
    - Greater than 75th percentile is correlated with a high degree of risk, **entirely independent** of the CAC score.
    - Males had higher calcified levels than females.
    - The amount and presence of calcium continually increased with age.
    - In both male and female, caucasians had the highest scores.

Prognostic Data for Coronary Heart Disease

- CAC has been shown to be more effective in defining the relative risk of developing coronary artery disease when compared to either individually or collectively generated accepted risk factors, that is, high sensitivity CRP, hypertension, lipid levels, family history, and IMT (Intima Media Thickness).

Multi-ethnic study of ASHD (The MESA Study)

- Sponsored by the National Heart Lung and Blood Institute
- 6814 asymptomatic individuals were followed for almost 15 years
- Hazard ratios for a coronary event
    - Calcium Score 101-300 7.73x greater risk than those of a score of 0
    - Calcium Score >300 9.67x greater risk than those with a score of 0
        - Doubling the CAC results in an increased risk of 18-39%
        - Calcium density was proportionate to the risk (the higher the density of calcium, the higher the risk and death rates showed the same relationship).

Summary of CAC Absolute Event Rates from 14856 patients in Five Prospective Studies

CAC Score	FRS Equivalent (Framingham Risk Score)	10 Yr Even Rate % Percentage
0	Very low	1.1 to 1.7%
1-100	Low	2.3 to 5.9%
101-400	Intermediate	12.8 to 16.4%
Greater than 400	High	22.5 to 28.6%
Greater than 1000	Very High	37%

Non Calcified Plaques

- Present in 4% of asymptomatic patients
- Present in 5% of acute ischemic syndromes
- Absence of calcified plaque conveys an extraordinary low ten year risk, (1.1-1.7%) irrespective of the number of risk factors.
- Correlating the CAC with the Framingham Risk Score -C statistic elevates the specificity from .73 to .84.
- Evaluating the effect of biomarker combinations (high sensitivity CRP, interleukin 8, myeloperoxidase, B-type Natriuretic Peptide, and plasminogen activator Type 1) **added nothing** to the FRS and CAC score of .84.

Congestive Heart Failure

- This test is useful in differentiating from non-ischemic cardiomyopathies.
- In 120 patients with congestive heart failure of unknown etiology, Budoff demonstrated the presence of CAC with a 99% sensitivity for an ischemic etiology for the cardiomyopathy.
- 1897 asymptomatic patients studied in Rotterdam clearly showed that with an increasing CAC score, a significantly higher risk for CHF was evident.

Stroke

All the evidence from the studies performed clearly indicate that as the CAC scores increased, so did the risk of stroke. Two studies in particular, Heinz, Nixdorf Recall Study of 4,180 asymptomatic patients and the MESA study of 6,779 asymptomatic patients.

- The median CAC score in whom stroke developed was 105

Diabetes

Although diabetes mellitus is considered in and of itself to be a risk equivalent to having coronary artery disease

- Diabetics with greater than 0 CAC score have a higher risk than those without diabetes and a similar CAC score

BUT

- Asymptomatic diabetics with the absence of CAC have a similar risk profile to patients without diabetes

Family History of Premature Coronary Artery Disease

There is a strong association between family history and both clinical and subclinical coronary heart disease

- Younger patients with a family history have significantly higher CAC scores
- The odds ratio for the presence of CAC in those with a positive family history independent of all risk factors, in comparison to those patients without a family history of coronary heart disease
    - One parent and a sibling results in a 2.74x increase of premature CHD
    - One sibling alone-2.06x premature CHD
    - One parent alone, 1.52x premature CHD
    - In the Dallas Heart Study 2,390 asymptomatic patients who were followed for eight years, the event rates for coronary heart disease **WERE ALMOST TRIPLE** for those with a family history plus CAC, compared to those with CAC and no family history of CHD.

Post CAC Scanning Patient

The appropriateness of stress testing after CAC scanning is directly related to the CAC score. It is only in the greater than 400 group that the pre-test likelihood is high enough to warrant further evaluation with myocardial perfusion imaging.

- Coronary CT angiography is feasible in patients with a CAC score greater than 1000
- It is **NEVER appropriate** to proceed directly to the cath lab in asymptomatic patients.
- In both older and younger populations, CAC efficiently uncovers **higher risk** patients who most need to be treated and who will most benefit from therapy, **irrespective** of lipid or CRP abnormalities

CAC Progression and Serial Scanning

Every outcome study concluded that **progression** of calcified plaque is associated with a worse prognosis.

Progression of CAC and Risk of First MI in 495 Patients Receiving Cholesterol Lowering Therapy

- Left sided CAC-with the progression of less than 15% per year indicates a benign prognosis irrespective of baseline CAC
- Right sided CAC-with a progression of more than 15% per year indicates a poor prognosis which is directly related to baseline CAC and implies inadequacy of treatment.
- Repeat CAC scanning may be used to determine the response and efficacy of treatment.
- A significant increase in calcified plaque speaks for treatment failure.
    - The only other method for assessing ongoing risk is the occurrence of an event (MI) or the development of symptoms (angina).
    - Excessive increases in CAC offers a chance to intervene with more aggressive therapy
    - This as yet has not been clinically documented with double blind studies

Repeat Scan Interval

- Asymptomatic patients with a CAC score of 0 should be rescanned in four years or more

Conclusions

For decades, we as healthcare providers have looked for ways of assessing risk for coronary artery disease, stroke and congestive heart failure in patients under our care. This has focused on hypertension, obesity, family history, lipid studies, CRP levels, Interleukin 8, myeloperoxidase levels, BNP, plasminogen activator Type 1, as well as coronary intima media thickness. **Nothing** has the predictive value of coronary artery calcium scanning for the development of adverse coronary events, namely MI, Stroke, and CHF.

Insurance, as yet, does not cover this examination, but the cost is dropping and now is quoted as $75 at NCH Imaging. Future double blind, peer reviewed studies need to be undertaken to prove its efficacy and cost benefits. Although it is no longer ridiculed, it is still violently opposed and someday will be considered self-evident.

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