Inflammation and Atherothrombosis: Where Have We Been? Where Are We Going? Why Perform the CIRT and CANTOS Trials? From Bench to Bedside to Population and Back: A Story of Clinical Translation

Paul M. Ridker
Harvard Medical School

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Inflammation and Atherothrombosis: Where have we been? Where Are We Going? Why Perform the CIRT and CANTOS Trials?

From Bench to Bedside to Population and Back: A Story of Clinical Translation

Paul M Ridker, MD
Eugene Braunwald Professor of Medicine
Harvard Medical School
Director, Center for Cardiovascular Disease Prevention
Brigham and Women’s Hospital, Boston MA
What is translational research?
How does an integrated health care system support it?

Bench → Bedside → Population

Affiliated Network Hospitals Clinics

T1, T2, T3
Dr Ridker has received investigator-initiated research support from the NHLBI, NCI, American Heart Association, Donald W Reynolds Foundation, Leduc Foundation, Doris Duke Charitable Foundation, AstraZeneca, Novartis, and SanofiAventis.

Dr Ridker has served as a consultant to Vascular Biogenics, Merck, ISIS, and Genzyme.

Dr Ridker is listed as a co-inventor on patents held by the Brigham and Women’s Hospital (BWH) that relate to the use of inflammatory biomarkers in cardiovascular disease and diabetes that have been licensed to Siemens and AstraZeneca. Dr. Ridker and the BWH receive royalties on sales of the hsCRP test. However, neither Dr. Ridker nor the BWH receives any royalties attributable to sales of the hsCRP test used in connection with the CIRT or CANTOS trials.
Inflammation, Atherothrombosis, and Vascular Prevention: Three Translational Questions

Is there evidence that individuals with elevated levels of inflammatory biomarkers are at high vascular risk even when other risk factors are acceptable? 1995-2002

Is there evidence that individuals identified at increased risk due to inflammation benefit from a therapy they otherwise would not have received? 2002-2008

Is there evidence that reducing inflammation per se will reduce vascular events? 2009 -
IL-6 and Risk of Future MI in Apparently Healthy Men

Ridker et al, Circulation 2000;101:1767-1772
hsCRP and Risk of Future MI and CVA in Apparently Healthy Men

hsCRP and Risks of Future MI: Analysis Stratified by Year of Follow-Up

hsCRP, Aspirin, and Risks of Future Myocardial Infarction

Event-Free Survival According to Baseline Quintiles of hs-CRP and LDL Cholesterol

Quintiles of hsCRP

Quintiles of LDL

CVD Event-Free Survival Probability

Years of Follow-Up

sICAM1
VCAM
P-selectin
Eselectin
IL-6, IL-18
IL1ra
TNF / YKL-40

Markers of Inflammation in the Prediction of Cardiovascular Disease in Women

Ridker et al. NEJM. 2000;342:836–43.
Markers of Inflammation in the Prediction of Cardiovascular Disease in Women

Ridker et al NEJM. 2000;342:836–43.
CRP, IL-6 and the Risk for Developing Type-2 Diabetes in the Women’s Health Study

Pradhan et al. JAMA 2001; 286:327-34
Linear Relationship of Inflammation to Vascular Risk Across a Very Wide Range of Values

Relative Risk of Future CV Events

- **“lower risk”** < 1 mg/L
- **“moderate risk”** 1 – 3 mg/L
- **“higher risk”** > 3 mg/L

hsCRP (mg/L)

Meta-analysis of 54 Prospective Cohort Studies
hsCRP concentration and risk of cardiovascular events: 2010

Coronary Heart Disease

All Vascular Deaths

Emerging Risk Factor Collaborators, Lancet January 2010
Direct Comparison of Lipid Markers and hsCRP in 166,596 Individuals Followed For First-Onset Cardiovascular Disease (ERFC NEJM 2012;367:1310-1320)

Multivariable Hazard Ratio for CVD per 1-SD change (adjusted for Age, Gender, Smoking, DM, BP, and HDL)
Direct Comparison of Lipid Markers and hsCRP in 166,596 Individuals Followed For First-Onset Cardiovascular Disease (ERFC NEJM 2012;367:1310-1320)

Multivariable Hazard Ratio for CVD per 1-SD change (adjusted for Age, Gender, Smoking, DM, BP, and HDL)

Non-lipid risk factors
- plus TC
- plus TC plus HDLC
- plus TC plus HDLC plus hsCRP

Change in C-statistic (as compared with non-lipid-based model)

hsCRP
Total Cholesterol

1.20 (1.18-1.22)
1.17 (1.15-1.19)
C-Reactive Protein and Reclassification of Cardiovascular Risk in the Framingham Heart Study

Peter W.F. Wilson, MD; Michael Pencina, PhD; Paul Jacques, DS; Jacob Selhub, PhD; Ralph D’Agostino, Sr, PhD; Christopher J. O’Donnell, MD, MPH

Background—The relationship of circulating levels of high-sensitivity C-reactive protein (CRP) with cardiovascular disease (CVD) risk, particularly with consideration of effects at intermediate levels of risk, has not been fully assessed.

Methods and Results—Among 3006 offspring participants in the Framingham Heart Study free of CVD (mean age, 46 years at baseline), there were 129 hard coronary heart disease (CHD) events and 286 total CVD events during 12 years of follow-up. Cox regression, discrimination with area under the receiver operating characteristic curve, and net reclassification improvement were used to assess the role of CRP on vascular risk. In an age-adjusted model that included traditional risk factors and CRP, the reclassification improvement in the discrimination of events was 11.8 % for hard CHD (P= 0.009), a value greater than that of LDL, HDL, or blood pressure in the Framingham Data. The net reclassification improvement when CRP was added to traditional factors was 5.6% for total CVD (P=0.014) and 11.8% for hard CHD (P=0.009).

Conclusions—Circulating levels of CRP help to estimate risk for initial cardiovascular events and may be used most effectively in persons at intermediate risk for vascular events, offering moderate improvement in reclassification of risk. (Circ Cardiovasc Qual Outcomes. 2008;1:92-97.)

Key Words: epidemiology ■ inflammation ■ risk factors ■ statistics
Reynolds Risk Score

Age Smoking SBP TC HDLC hsCRP Family History HbA1c

hsCRP (mg/L) is not CRP (mg/dL)

If you are healthy and without diabetes, the Reynolds Risk Score is designed to predict your risk of having a future heart attack, stroke, or other major heart disease in the next 10 years.

In addition to your age, blood pressure, cholesterol levels and whether you currently smoke, the Reynolds Risk Score uses information from two other risk factors, a blood test called hsCRP (a measure of inflammation) and whether or not either of your parents had a heart attack before they reached age 60 (a measure of genetic risk). To calculate your risk, fill in the information below with your most recent values. Click here for help filling the information.

Gender

- Male
- Female

Age

- Years (Maximum age must be 80)

Do you currently smoke?

- Yes
- No

Systolic Blood Pressure (SBP)

- 125 mm/Hg

Total Cholesterol

- 230 mg/DL

HDL or "Good" Cholesterol

- 45 mg/DL

High Sensitivity C-Reactive Protein (hsCRP)

- 4.5 mg/L

Did your Mother or Father have a heart attack before age 60?

- Yes
- No

Calculate 10 year risk

As shown in the graph below, at Age 68, your chance of having a heart attack, stroke, or other heart disease event at some point in the next 10-years is 29 percent. This risk is approximately 3 times higher than that of a man the same age who has optimal levels of all modifiable risk factors.

Your 10-year risk (age 68) is 29%

Your 10-year risk (age 68) if:

- your blood pressure was 120
- your cholesterol was 160
- your hsCRP was 0.5
- all the above were optimal

The graph above also compares your risk to that of a man of age 68 who has optimal levels for all modifiable risk factors, and shows what your risk would be if you improved your individual risk factors. For young men, risk may appear to be low over the next 10-years, yet can be very high over a lifetime. Thus, to see what your risk would be as you get older if your risk factors remain the same, click on the buttons above.
Comparison of the Framingham and Reynolds Risk Scores for Global Cardiovascular Risk Prediction in the Multiethnic Women’s Health Initiative

Nancy R. Cook, ScD; Nina P. Paynter, PhD; Charles B. Eaton, MD; JoAnn E. Manson, MD, DrPH; Lisa W. Martin, MD; Jennifer G. Robinson, MD, MPH; Jacques E. Rossouw, MD; Sylvia Wassertheil-Smoller, PhD; Paul M Ridker, MD

Background—Framingham-based and Reynolds Risk scores for cardiovascular disease (CVD) prediction have not been directly compared in an independent validation cohort.

Methods and Results—We selected a case-cohort sample of the multiethnic Women’s Health Initiative Observational Cohort, comprising 1722 cases of major CVD (752 myocardial infarctions, 754 ischemic strokes, and 216 other CVD deaths) and a nested cohort of 4891 women without prior CVD. We estimated risks using the Adult Treatment Panel (ATP) III and the Reynolds Risk Score. The Reynolds Risk Score was better calibrated than the Framingham model in this large external validation cohort. The Reynolds score also showed improved discrimination overall in black and white women. Large differences in risk estimates exist between models, with clinical implications for statin therapy.

P=0.02), and positive integrated discrimination improvement (4.1%; P<0.0001) overall, excluding diabetics (NRI=4.2%; P=0.01), and in white (NRI=4.3%; P=0.04) and black (NRI=11.4%; P=0.13) women. The Reynolds (NRI=12.9%; P<0.0001) and ATP-III (NRI=5.9%; P=0.0001) models demonstrated better discrimination than the Framingham CVD model.

Conclusions—The Reynolds Risk Score was better calibrated than the Framingham-based models in this large external validation cohort. The Reynolds score also showed improved discrimination overall and in black and white women. Large differences in risk estimates exist between models, with clinical implications for statin therapy. (Circulation. 2012;125:1748-1756.)
55 year old executive
Chief complaint
Stress and anxiety
No prior CV history
Non-smoker, no diabetes
Close associate recurrent MI
“elevated CRP”

TC 170
HDL 42
LDL 112
TG 80
hs-CRP 0.6
55 year old executive
Chief complaint
Stress and anxiety
No prior CV history
Non-smoker, no diabetes
Close associate recurrent MI
“elevated CRP”

TC 170
HDL 42
LDL 112
TG 80
hs-CRP 0.6
Checkup Finds Bush Fit and Healthy

By LAWRENCE K. ALTMAN

WASHINGTON, Aug. 4 — President Bush is in “outstanding health” and at very low risk for a heart attack, his doctors said today after performing Mr. Bush’s first medical checkup since he took office.

Mr. Bush was monitored while he ran on a treadmill for 25 minutes with a maximum heart rate of 178 beats per minute. The findings placed him “in the top 2 percent of men his age in cardiovascular fitness,” a White House statement signed by 14 doctors said.

Mr. Bush, 55, runs an average of three miles four times a week. He also swims, lifts weights and uses an elliptical trainer. His resting heart rate was reported as 43 beats a minute and his blood pressure as 118/74.

Mr. Bush, who is six feet tall, has lost nearly five pounds in the last year. His weight of 189.75 pounds is down from 194.5 pounds at his last checkup in June 2000, when he was governor of Texas. His body fat is normal at 14.5 percent, down from 19.94 percent.

“I’m in pretty good shape,” Mr. Bush said after after completing the 5-hour, 50-minute examination at Bethesda Naval Hospital.

The only new abnormality reported was the removal of three potentially cancerous lesions from Mr. Bush’s face. Dr. Richard A. Keller, the chief dermatologist at Walter Reed Army Medical Center, used liquid nitrogen to remove the lesions, which are known as actinic keratoses. They are common and result from chronic sun exposure; if untreated, a small percentage of them can become skin cancers.

A White House spokesman described them as “small, dry patches” that had a red tint and felt “like sandpaper.”

In 1998 and 1999, Mr. Bush had benign polyps removed from his colon after a routine examination. Another colonoscopy is not due until next year, the doctors said. Ultrasound tests of his abdomen performed today were normal.

Tests showed no change in Mr. Bush’s mild high-frequency hearing loss, which does not affect his normal conversations.

A set of 70 blood and urine tests were all normal. They included tests for risk of heart disease: total cholesterol, 170; high density lipoprotein, 42; low density lipoprotein, 112; triglycerides 80; C-reactive protein, 0.4; and homocysteine, 8.6. A standard blood test for prostate cancer was a normal 0.78.

Mr. Bush suffers from seasonal allergies, wears reading glasses, smokes an occasional cigar and does not drink alcohol, according to the statement.

He takes vitamins but does not routinely use prescription medications and has not missed a day of work since his last checkup. The examination was performed by Dr. Kenneth H. Cooper of Dallas, who has given Mr. Bush annual checkups since 1989.

Dr. Cooper joined Dr. Richard J. Tubb, the White House physician, in supervising today’s checkup.

The 14 doctors used a standard military phrase to describe Mr. Bush as “fit for duty.” All but four of the doctors work at military hospitals. They also said, “All data suggest that he will remain so for the duration of his presidency.”
Doctors Who Examine Bush Say He Is Exceptionally Fit

By LAWRENCE K. ALTMAN

WASHINGTON, Aug. 6 — President Bush's second annual medical checkup since he took office found him in "extraordinary health," his doctors said today, with his heart and lung function in the top 1 percent for men of his age, up from the top 2 percent a year ago.

The three-hour battery of tests that Mr. Bush, 56, underwent this morning show that he has no evidence of heart disease and a "very low" risk for a heart attack, the doctors said. They predicted that he would remain in excellent health for the rest of his term.

As Mr. Bush returned to the White House from the National Naval Medical Center in nearby Bethesda, Md., where the checkup was performed, he said he was "feeling good." Later, Mr. Bush flew to his ranch in Texas for a monthlong working vacation.

In a five-page detailed statement released by the White House, the team of eight military and civilian doctors and health specialists who examined the president said that Mr. Bush had not missed work due to illness in the White House and that he had not had a recurrence of the fainting episode he suffered in January when a pretzel stuck in his throat.

Mr. Bush fell off a sofa and cut his face in the fainting incident, which the White House said occurred while he was watching television.

Mr. Bush smokes an occasional cigar, abstains from alcohol and drinks diet sodas and coffee, the doctors said. Mr. Bush, who stands six feet tall, weighed 189 pounds, three-quarters of a pound less than at the checkup in August 2001. His body fat remained unchanged at 14.5 percent and down from 19.94 percent recorded in a checkup in June 2000.

He takes vitamins and an aspirin daily. Mr. Bush does not routinely use prescription medications except for a steroid nasal spray to prevent symptoms in allergy seasons.

The only abnormalities noted involved his hearing, skin and eyes.

Mr. Bush has a high frequency hearing loss in both ears from 4,000 to 8,000 kilohertz that is unchanged from last year's examination. Mr. Bush's hearing is excellent in the frequencies for speech, the doctors said. They also said that the degree and frequency involved do not affect normal conversation.

The doctors said that the small harmless red blotches that appear on Mr. Bush's nose are due to widened capillaries resulting from sun exposure. No treatment was given today, but they said that it may be needed in the future for the condition, known as telangiectasias. It is common.

In the last year, four small benign skin growths were removed from Mr. Bush's face.

Mr. Bush occasionally uses reading glasses.

Mr. Bush is a fitness enthusiast, and his heart rate of 44 beats a minute and blood pressure of 106/70 reflects his training routine. He typically runs three miles four times a week, with average times from 6:45 minutes to 7:15 minutes a mile. He also routinely cross-trains with free weights for 45 minutes twice a week and an elliptical trainer.

In an exercise treadmill test during the checkup, Mr. Bush ran for 27:02 minutes with a maximum heart rate of 189, or 97 percent of predicted heart rate, compared to 26 minutes last year.

An echocardiogram, or ultrasound test of the heart, was normal.

Blood tests showed that Mr. Bush's total cholesterol was in the "desirable" level, at 177. His high density lipoprotein (HDL) was normal at 49. His low density lipoprotein (LDL) was in the "desirable/near optimal" level of 114, and the ratio of the total cholesterol to HDL was optimal at 3.6, the doctors said.

Additional tests for potential heart disease were also normal. They included triglycerides (99) and homocysteine (7.1). A test for C-reactive protein was 0.6, putting him in the lowest risk category.

An annual physical shows the president to be in better shape than last year.
Inflammation, Atherothrombosis, and Vascular Prevention: Three Translational Questions

Is there evidence that individuals with elevated levels of inflammatory biomarkers are at high vascular risk even when other risk factors are acceptable? 1995-2002

Is there evidence that individuals identified at increased risk due to inflammation benefit from a therapy they otherwise would not have received? 2002-2008

Is there evidence that reducing inflammation per se will reduce vascular events? 2009 -
Inflammation, Statin Therapy, and hsCRP: Initial Observations

*P Trend = 0.005*

Relative Risk

- Pravastatin
- Placebo

<table>
<thead>
<tr>
<th></th>
<th>Inflammation Absent</th>
<th>Inflammation Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pravastatin</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Placebo</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

-21.6% (P=0.004)

Median hs-CRP (mg/dL)

Baseline: 0.23
5 Years: 0.18


Clinical Relevance of Achieved LDL and Achieved CRP After ACS Treated with Statin Therapy

Clinical Relevance of Achieved LDL and Achieved CRP After ACS Treated with Statin Therapy

Follow-Up (Years)

LDL > 70 mg/dL, CRP > 2 mg/L

LDL < 70 mg/dL, CRP > 2 mg/L

LDL > 70 mg/dL, CRP < 2 mg/L

LDL < 70 mg/dL, CRP < 2 mg/L

“dual targets for statin therapy”

Primary Prevention: Whom Should We Treat?

Probability of Event-free Survival

- hsCRP < 2, LDL < 130
- hsCRP > 2, LDL < 130
- hsCRP < 2, LDL > 130
- hsCRP > 2, LDL > 130

Years of Follow-up

hsCRP as a Method to Target Statin Therapy in Primary Prevention: AFCAPS/TexCAPS

<table>
<thead>
<tr>
<th>Study Group</th>
<th>Statin</th>
<th>Placebo</th>
<th>NNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>low LDLC / low CRP</td>
<td>0.025</td>
<td>0.022</td>
<td>----</td>
</tr>
<tr>
<td>low LDLC / high CRP</td>
<td>0.029</td>
<td>0.051</td>
<td>48</td>
</tr>
<tr>
<td>high LDLC / low CRP</td>
<td>0.020</td>
<td>0.050</td>
<td>33</td>
</tr>
<tr>
<td>high LDLC / high CRP</td>
<td>0.038</td>
<td>0.055</td>
<td>58</td>
</tr>
</tbody>
</table>

Median LDLC = 150 mg/dL
Median CRP = 2 mg/L

JUPITER
Multi-National Randomized Double Blind Placebo Controlled Trial of Rosuvastatin in the Prevention of Cardiovascular Events Among Individuals With Low LDL and Elevated hsCRP

Ridker et al NEJM 2008;359:2195-2207

Argentina, Belgium, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Denmark, El Salvador, Estonia, Germany, Israel, Mexico, Netherlands, Norway, Panama, Poland, Romania, Russia, South Africa, Switzerland, United Kingdom, Uruguay, United States, Venezuela

Mean LDLC 104 mg/dL, Mean HDLC 50 mg/dL, hsCRP 4 mg/L
JUPITER
Primary Trial Endpoint: MI, Stroke, UA/Revascularization, CV Death

HR 0.56, 95% CI 0.46-0.69
P < 0.00001

Number Needed to Treat (NNT₅) = 25

Ridker et al NEJM 2008;359:2195-2207
JUPITER
Fatal or Nonfatal Myocardial Infarction

Ridker et al NEJM 2008;359:2195-2207

HR 0.45, 95% CI 0.30-0.70
P < 0.0002

Cumulative Incidence

Follow-up Years

0.000
0.005
0.010
0.015
0.020
0.025
0.030

0 1 2 3 4

Follow-up Years

0.000
0.005
0.010
0.015
0.020
0.025
0.030

0 1 2 3 4

Follow-up Years

HR 0.45, 95% CI 0.30-0.70
P < 0.0002

Placebo

Rosuvastatin

- 55 %
JUPITER
Fatal or Nonfatal Stroke

Ridker et al. NEJM 2008;359:2195-2207

HR 0.52, 95% CI 0.34-0.79
P = 0.002
JUPITER
Arterial Revascularization / Unstable Angina

**HR 0.53, 95% CI 0.40-0.70, P < 0.00001**

**Placebo (N = 143)**

**Rosuvastatin (N = 76)**

**Cumulative Incidence**

**Number at Risk**

<table>
<thead>
<tr>
<th>Follow-up (years)</th>
<th>Rosuvastatin</th>
<th>Placebo</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>8,901</td>
<td>8,901</td>
</tr>
<tr>
<td>1</td>
<td>8,640</td>
<td>8,640</td>
</tr>
<tr>
<td>2</td>
<td>8,426</td>
<td>8,390</td>
</tr>
<tr>
<td>3</td>
<td>6,550</td>
<td>6,542</td>
</tr>
<tr>
<td>4</td>
<td>3,905</td>
<td>3,895</td>
</tr>
<tr>
<td>5</td>
<td>1,966</td>
<td>1,977</td>
</tr>
<tr>
<td>6</td>
<td>1,359</td>
<td>1,346</td>
</tr>
<tr>
<td>7</td>
<td>989</td>
<td>963</td>
</tr>
<tr>
<td>8</td>
<td>547</td>
<td>538</td>
</tr>
<tr>
<td>9</td>
<td>158</td>
<td>176</td>
</tr>
</tbody>
</table>

Ridker et al NEJM 2008;359:2195-2207
JUPITER
Secondary Endpoint – All Cause Mortality

HR 0.80, 95% CI 0.67-0.97
P = 0.02

Placebo 247 / 8901
- 20%

Rosuvastatin 198 / 8901

NEJM 2008;359:2195-2207
JUPITER
Primary Endpoint - Understudied or “Low Risk” Subgroups

Understudied Subgroups

Women
Age > 70
Black, Hispanic, Other

“Low Risk” Subgroups

Framingham Risk < 10 %
BMI < 25 mg/m2
No Hypertension
No metabolic Syndrome

All Participants

<table>
<thead>
<tr>
<th>Subgroup</th>
<th>N</th>
<th>HR (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Women</td>
<td>6,801</td>
<td>0.54 (0.37-0.80)</td>
</tr>
<tr>
<td>Age &gt; 70</td>
<td>5,695</td>
<td>0.61 (0.46-0.82)</td>
</tr>
<tr>
<td>Black, Hispanic, Other</td>
<td>5,117</td>
<td>0.63 (0.41-0.98)</td>
</tr>
<tr>
<td>Framingham Risk &lt; 10 %</td>
<td>8,882</td>
<td>0.56 (0.38-0.83)</td>
</tr>
<tr>
<td>BMI &lt; 25 mg/m2</td>
<td>4,073</td>
<td>0.59 (0.40-0.87)</td>
</tr>
<tr>
<td>No Hypertension</td>
<td>7,586</td>
<td>0.62 (0.44-0.87)</td>
</tr>
<tr>
<td>No metabolic Syndrome</td>
<td>10,296</td>
<td>0.49 (0.37-0.65)</td>
</tr>
<tr>
<td>All Participants</td>
<td>17,802</td>
<td>0.56 (0.46-0.69)</td>
</tr>
</tbody>
</table>

Ridker et al NEJM 2008;359:2195-2207
## JUPITER
### Adverse Events and Measured Safety Parameters

<table>
<thead>
<tr>
<th>Event</th>
<th>Rosuvastatin</th>
<th>Placebo</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any SAE</td>
<td>1,352 (15.2)</td>
<td>1,337 (15.5)</td>
<td>0.60</td>
</tr>
<tr>
<td>Muscle weakness</td>
<td>1,421 (16.0)</td>
<td>1,375 (15.4)</td>
<td>0.34</td>
</tr>
<tr>
<td>Myopathy</td>
<td>10 (0.1)</td>
<td>9 (0.1)</td>
<td>0.82</td>
</tr>
<tr>
<td>Rhabdomyolysis</td>
<td>1 (0.01)*</td>
<td>0 (0.0)</td>
<td>--</td>
</tr>
<tr>
<td>Incident Cancer</td>
<td>298 (3.4)</td>
<td>314 (3.5)</td>
<td>0.51</td>
</tr>
<tr>
<td>Cancer Deaths</td>
<td>35 (0.4)</td>
<td>58 (0.7)</td>
<td>0.02</td>
</tr>
<tr>
<td>Hemorrhagic stroke</td>
<td>6 (0.1)</td>
<td>9 (0.1)</td>
<td>0.44</td>
</tr>
</tbody>
</table>

**GFR (ml/min/1.73m² at 12 mth)**
- Rosuvastatin: 66.8 (59.1-76.5)
- Placebo: 66.6 (58.8-76.2)
- P: 0.02

**ALT > 3xULN**
- Rosuvastatin: 23 (0.3)
- Placebo: 17 (0.2)
- P: 0.34

**Fasting glucose (24 mth)**
- Rosuvastatin: 98 (91-107)
- Placebo: 98 (90-106)
- P: 0.12

**HbA1c (% at 24 mth)**
- Rosuvastatin: 5.9 (5.7-6.1)
- Placebo: 5.8 (5.6-6.1)
- P: 0.01

**Glucosuria (12 mth)**
- Rosuvastatin: 36 (0.5)
- Placebo: 32 (0.4)
- P: 0.64

**Incident Diabetes**
- Rosuvastatin: 270 (3.0)
- Placebo: 216 (2.4)
- P: 0.01

*Occurred after trial completion, trauma induced.  All values are median (interquartile range) or N (%)*

**Physician reported**
JUPITER
Statins and the Development of Diabetes

<table>
<thead>
<tr>
<th>Trial</th>
<th>Statin</th>
<th>HR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WOSCOPS</td>
<td>Pravastatin</td>
<td>0.70 (0.50–0.98)</td>
</tr>
<tr>
<td>(Hypothesis Generating Trial)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PROSPER</td>
<td>Pravastatin</td>
<td>1.34 (1.06–1.68)</td>
</tr>
<tr>
<td>LIPID</td>
<td>Pravastatin</td>
<td>0.91 (0.72–1.18)</td>
</tr>
<tr>
<td>HPS</td>
<td>Simvastatin</td>
<td>1.20 (0.98–1.35)</td>
</tr>
<tr>
<td>ASCOT-LLA</td>
<td>Atorvastatin</td>
<td>1.20 (0.91–1.44)</td>
</tr>
<tr>
<td>PROVE-IT</td>
<td>Atorvastatin</td>
<td>1.11 (0.67–1.83)</td>
</tr>
<tr>
<td></td>
<td>vs Pravastatin</td>
<td></td>
</tr>
<tr>
<td>CORONA</td>
<td>Rosuvastatin</td>
<td>1.13 (0.86–1.50)</td>
</tr>
<tr>
<td>JUPITER</td>
<td>Rosuvastatin</td>
<td>1.25 (1.05–1.54)</td>
</tr>
<tr>
<td>(Hypothesis Testing Trials)</td>
<td></td>
<td>1.12 (1.04–1.30)</td>
</tr>
</tbody>
</table>
Incident Diabetes Limited to Those With Impaired Fasting Glucose

Ridker et al. Lancet 2012;380:

- Placebo
- Rosuvastatin

Fasting Glucose Level (mg/dL)
- <100: (51) (62)
- 100-104: (18) (43)
- 105-109: (39) (38)
- 110-114: (34) (53)
- 115-119: (34) (39)
- 120-125: (39) (45)
**JUPITER**

Statin Highly Effective in All Patients – Primary Endpoint

Ridker et al Lancet 2012

**Impaired Fasting Glucose**

HR 0.69, 95% CI 0.49-0.98

**Normal Fasting Glucose**

HR 0.51, 95% CI 0.40-0.67
Cardiovascular Benefits and Diabetes Risks of Statin Therapy in Primary Prevention: The JUPITER Trial

- In absolute terms for those without a major diabetes risk factor, 86 vascular events or death were avoided by statin therapy with no excess cases of diabetes diagnosed.
- In absolute terms for those with a major diabetes risk factor, 134 vascular events or deaths were avoided by statin therapy for every 54 new cases of diabetes diagnosed.
- Statin therapy increased the time to diagnosis of diabetes by 5.4 weeks.
- Conclusion: In primary prevention, the cardiovascular and mortality benefits of statin therapy exceed the diabetes hazard, including among individuals at high risk for developing diabetes. Long-term microvascular effects unknown.
“The initial step in risk assessment in individual patients involves the ascertainment of a global risk score (Framingham, Reynolds, etc) and the elucidation of a family history of atherosclerotic CVD. These Class I recommendations which are simple and inexpensive determine subsequent strategies to be undertaken”

Reynolds = Framingham + hsCRP + family history
### Primary Goal: LDLC

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>LDL Goals</th>
<th>Class</th>
<th>Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>CAD, CVA, PVD</td>
<td>&lt;2mmol/L or 50% reduction</td>
<td>Class I</td>
<td>Level A</td>
</tr>
<tr>
<td></td>
<td>Most pts with Diabetes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FRS &gt; 20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>RRS &gt; 20%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>FRS 10-19%</td>
<td>&lt;2mmol/L or 50% reduction</td>
<td>Class IIA</td>
<td>Level A</td>
</tr>
<tr>
<td></td>
<td>RRS 10-19%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LDL &gt; 3.5 mmol/L</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>TC/HDLC &gt; 5.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>hsCRP &gt; 2 in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>men &gt;50 yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>women &gt; 60 yr</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>FRS &lt; 10%</td>
<td>&lt;5mmol/L</td>
<td>Class IIA</td>
<td>Level A</td>
</tr>
</tbody>
</table>

### Secondary Targets:
- TC/HDLC < 4, non HDLC < 3.5 mol/L,
- hsCRP < 2 mg/L, TG < 1.7 mol/L, ApoB/A < 0.8
Guidelines: Statin Therapy in Primary Prevention
What works and in whom?

 Benefit
 Untested

 Low LDL
 Low hsCRP
 High HDL

 High LDL

 High hsCRP

 Low HDL

 WOSCOPS
 HR 0.70 (0.57-0.84)
 MEGA
 HR 0.67 (0.49-0.91)
 (pravastatin)

 JUPITER
 HR 0.56 (0.46-0.69)
 (rosuvastatin)

 AFCAPS/TexCAPS
 HR 0.63 (0.50-0.79)
 (lovastatin)

 Circ Cardiovasc Qual Outcomes 2012;5:592-3
 Eur Heart J 2013;34:1258-61
JUPITER
Consistent Effects in All Geographic Regions, All Pre-Specified Subgroups

USA  4021
Canada  2020
European Union  6023
Total  17802

Rosuvastatin Superior  Rosuvastatin Inferior

The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice (constituted by representatives of nine societies and by invited experts)

Developed with the special contribution of the European Association for Cardiovascular Prevention & Rehabilitation (EACPR)†

567 References - No mention of the JUPITER trial, No Change in Practice, No recognition by EMA
Inflammation, Atherothrombosis, and Vascular Prevention: Three Translational Questions

Is there evidence that individuals with elevated levels of inflammatory biomarkers are at high vascular risk even when other risk factors are acceptable? 1995-2002

Is there evidence that individuals identified at increased risk due to inflammation benefit from a therapy they otherwise would not have received? 2002-2008

Is there evidence that reducing inflammation per se will reduce vascular events? 2009 -
JUPITER
Achieved LDLC, Achieved hsCRP, or Both?

The Real Controversy:
Is the large benefit observed in the JUPITER trial due to lipid lowering, to inflammation inhibition, or to a combination of these two processes?
Inflammation and Thrombosis

- Resting Endothelial Cell
- Activated Endothelial Cell
- Activated Macrophage
- Activated Degranulating Platelet
- Resting Platelet
- Proliferating Modulated Smooth Muscle Cell
- Reactive Oxygen Species
- Tissue Factor Procoagulant
- Pro-inflammatory Cytokines
- Lipid mediators Of inflammation

Pro-inflammatory Mediators (e.g., CD40L, RANTES, IL-6)
Venous Endothelium- *transmission electron micrograph*
**JUPITER**
Total Venous Thromboembolism

Glynn et al NEJM 2010

**HR 0.57, 95%CI 0.37-0.86  
P = 0.007**

Placebo 60 / 8901  
- 43 %

Rosuvastatin 34 / 8901

Number at Risk  
Rosuvastatin 8,901 8,648 8,447 6,574 3,927 1,986 1,376 1,003 548 161  
Placebo 8,901 8,652 8,417 6,574 3,943 2,012 1,381 993 556 182
Baseline hsCRP

<table>
<thead>
<tr>
<th>Baseline hsCRP</th>
<th>N</th>
</tr>
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<tbody>
<tr>
<td>&gt;10 mg/L</td>
<td>2,503</td>
</tr>
<tr>
<td>&gt;9 mg/L</td>
<td>3,071</td>
</tr>
<tr>
<td>&gt;8 mg/L</td>
<td>3,839</td>
</tr>
<tr>
<td>&gt;7 mg/L</td>
<td>4,723</td>
</tr>
<tr>
<td>&gt;6 mg/L</td>
<td>5,897</td>
</tr>
<tr>
<td>&gt;5 mg/L</td>
<td>7,425</td>
</tr>
<tr>
<td>&gt;4 mg/L</td>
<td>9,726</td>
</tr>
<tr>
<td>&gt;3 mg/L</td>
<td>12,939</td>
</tr>
<tr>
<td>&gt;2 mg/L</td>
<td>17,802</td>
</tr>
</tbody>
</table>

Better

Worse

Placebo Event Rate

Ridker et al, Am J Card 2010;106:206-9
**JUPITER**

**LDL reduction, hsCRP reduction, or both?**

<table>
<thead>
<tr>
<th>N</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo</td>
<td>7832</td>
</tr>
<tr>
<td>LDL&gt;70mg/dL, hsCRP&gt;2 mg/L</td>
<td>1384</td>
</tr>
<tr>
<td>LDL&lt;70mg/dL, hsCRP&gt;2 mg/L</td>
<td>2921</td>
</tr>
<tr>
<td>LDL&gt;70mg/dL, hsCRP&lt;2 mg/L</td>
<td>726</td>
</tr>
<tr>
<td>LDL&lt;70mg/dL, hsCRP&lt;2 mg/L</td>
<td>2685</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>N</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placebo</td>
<td>7832</td>
</tr>
<tr>
<td>LDL&gt;70mg/dL, hsCRP&gt;1 mg/L</td>
<td>1874</td>
</tr>
<tr>
<td>LDL&lt;70mg/dL, hsCRP&gt;1 mg/L</td>
<td>4662</td>
</tr>
<tr>
<td>LDL&gt;70mg/dL, hsCRP&lt;1 mg/L</td>
<td>236</td>
</tr>
<tr>
<td>LDL&lt;70mg/dL, hsCRP&lt;1 mg/L</td>
<td>944</td>
</tr>
</tbody>
</table>

**Full Adjusted Hazard Ratio**

0.21, 95% CI 0.09-0.52, P < 0.0001
JUPITER
LDL reduction, hsCRP reduction, or both?

JUPITER GWAS:

The genetic determinants of rosvuvastatin-induced LDL-C reduction do not predict rosvuvastatin-induced CRP reduction.

The genetic determinants of rosvuvastatin-induced CRP reduction do not predict rosvuvastatin-induced LDL-C reduction.

Chasman et al, 2012 Circulation Cardiovascular Genetics
Chu et al, 2012 Circulation Cardiovascular Genetics
Meta-analysis of 54 Prospective Cohort Studies: The magnitude of independent risk associated with inflammation is at least as large, if not larger, than that of BP and cholesterol

Adjusted for age, gender, smoking, diabetes, BMI, triglycerides, alcohol, lipid levels, and hsCRP

Emerging Risk Factor Collaborators, Lancet January 2010
Can Targeted Anti-Inflammatory Therapy Reduce Cardiovascular Event Rates and Prolong Life?
Testing the Inflammatory Hypothesis of Atherothrombosis: Do we attack the biomarker or attack the process?
Cardiovascular Inflammation Reduction Trial (CIRT)

Stable CAD (post MI) On Statin, ACE/ARB, BB, ASA

Persistent Evidence of Inflammation

What agent to study?

Anti-Inflammatory Intervention

Placebo

Nonfatal MI, Nonfatal Stroke, Cardiovascular Death, Incident T2DM

How to define?

Ridker PM. Thromb Haemost 2009
## Issues in the Selection of Anti-inflammatory Agents for Trials of Cardiovascular Inflammation Inhibition

<table>
<thead>
<tr>
<th></th>
<th>Statins</th>
<th>TNF inhibition</th>
<th>IL-6 Inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td>↓↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>LDL</td>
<td>↓↓</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>HDL</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>TG</td>
<td>↔</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>Chylo</td>
<td>↔</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>CRP / IL-6</td>
<td>↓</td>
<td>↓↓</td>
<td>↓↓</td>
</tr>
</tbody>
</table>
# Issues in the Selection of Anti-inflammatory Agents for Trials of Cardiovascular Inflammation Inhibition

<table>
<thead>
<tr>
<th></th>
<th>Statins</th>
<th>TNF inhibition</th>
<th>IL-6 Inhibition</th>
<th>LDM Inhibition</th>
<th>IL-1β Inhibition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td>↓↓</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td>LDL</td>
<td>↓↓</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td>HDL</td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td>TG</td>
<td>←→</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td>Chylo</td>
<td>←→</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td>CRP / IL-6</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
</tr>
</tbody>
</table>
## LDM and CVD: Observational Evidence

<table>
<thead>
<tr>
<th>Cohort</th>
<th>Group</th>
<th>HR* (95 % CI)</th>
<th>Endpoint</th>
<th>Exposure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wichita</td>
<td>RA</td>
<td>0.4 (0.2 - 0.8)</td>
<td>Total Mortality</td>
<td>LDM</td>
</tr>
<tr>
<td>Choi 2002</td>
<td></td>
<td>0.3 (0.2 - 0.7)</td>
<td>CV Mortality</td>
<td>LDM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.4 (0.3 – 0.8)</td>
<td>CV Mortality</td>
<td>LDM &lt; 15 mg/wk</td>
</tr>
<tr>
<td>Netherlands</td>
<td>RA</td>
<td>0.3 (0.1 – 0.7)</td>
<td>CVD</td>
<td>LDM only</td>
</tr>
<tr>
<td>van Helm 2006</td>
<td></td>
<td>0.2 (0.1 – 0.5)</td>
<td>CVD</td>
<td>LDM + SSZ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 (0.1 – 1.2)</td>
<td>CVD</td>
<td>LDM + HCQ</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.2 (0.1 – 0.5)</td>
<td>CVD</td>
<td>LDM + SSZ + HCQ</td>
</tr>
<tr>
<td>Miami VA</td>
<td>PsA</td>
<td>0.7 (0.6 – 0.9)</td>
<td>CVD</td>
<td>LDM</td>
</tr>
<tr>
<td>Pradanovich 2005</td>
<td></td>
<td>0.5 (0.3 – 0.8)</td>
<td>CVD</td>
<td>LDM &lt; 15 mg/wk</td>
</tr>
<tr>
<td></td>
<td>RA</td>
<td>0.8 (0.7 – 1.0)</td>
<td>CVD</td>
<td>LDM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.6 (0.5 – 0.8)</td>
<td>CVD</td>
<td>LDM &lt; 15 mg/wk</td>
</tr>
<tr>
<td>CORRONA</td>
<td>RA</td>
<td>0.6 (0.3 – 1.2)</td>
<td>CVD</td>
<td>LDM</td>
</tr>
<tr>
<td>Solomon 2008</td>
<td></td>
<td>0.4 (0.2 – 0.8)</td>
<td>CVD</td>
<td>TNF-inhibitor</td>
</tr>
<tr>
<td>QUEST-RA</td>
<td>RA</td>
<td>0.85 (0.8 – 0.9)</td>
<td>CVD</td>
<td>LDM</td>
</tr>
<tr>
<td>Narango 2008</td>
<td></td>
<td>0.82 (0.7 – 0.9)</td>
<td>MI</td>
<td>LDM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.89 (0.8 - 1.0)</td>
<td>Stroke</td>
<td>LDM</td>
</tr>
<tr>
<td>UK Norfolk</td>
<td>RA, PsA</td>
<td>0.6 (0.4 – 1.0)</td>
<td>Total Mortality</td>
<td>LDM</td>
</tr>
<tr>
<td>2008</td>
<td></td>
<td>0.5 (0.3 – 1.1)</td>
<td>CV Mortality</td>
<td>LDM</td>
</tr>
</tbody>
</table>
Methotrexate Inhibits Atherogenesis in Cholesterol-fed Rabbits

Bulgarelli et al, J Cardiovasc Pharmacol 2012;59:308-14
Cardiovascular Inflammation Reduction Trial (CIRT)

Primary Aims

- To directly test the inflammatory hypothesis of atherothrombosis
- To evaluate in a randomized, double-blind, placebo-controlled trial whether MTX given at a target dose of 20 mg po weekly over a three year period will reduce rates of recurrent myocardial infarction, stroke, or cardiovascular death among patients with a prior history of myocardial infarction and either type 2 diabetes or metabolic syndrome.

Stable CAD (post MI)
On Statin, ACE/ARB, BB, ASA

Persistent Evidence of Inflammation
Diabetes or Metabolic Syndrome

MTX 15-20 mg Weekly
Placebo

Nonfatal MI, Nonfatal Stroke, Cardiovascular Death

N = 7,000 NHLBI-Sponsored
Enrollment to Start March 2013
350 US and Canadian Sites
Cardiovascular Inflammation Reduction Trial (CIRT)
Forms, Updates, and More Information – theCIRT.org website

What is the Cardiovascular Inflammation Reduction Trial (CIRT)?
CIRT is a major new randomized trial sponsored by the US National Heart Lung and Blood Institute. CIRT will directly test whether a common anti-inflammatory drug used for the treatment of rheumatoid arthritis (low dose methotrexate) can reduce the risk of heart attack, stroke, and cardiovascular death in patients who have suffered a prior heart attack.

Why worry about inflammation?
Inflammation plays a major role in heart attack and stroke. While inflammation is as important as cholesterol and high blood pressure, no clinical trial has tested whether reducing inflammation can reduce rates of these life-threatening disorders.

Who is eligible for CIRT?
Men and women who have suffered a prior heart attack and who have either type 2 diabetes or metabolic syndrome, two conditions associated with a pro-inflammatory
# Issues in the Selection of Anti-inflammatory Agents for Trials of Cardiovascular Inflammation Inhibition

<table>
<thead>
<tr>
<th></th>
<th>Statins</th>
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</thead>
<tbody>
<tr>
<td><strong>TC</strong></td>
<td>↓↓</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td><strong>LDL</strong></td>
<td>↓↓</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td><strong>HDL</strong></td>
<td>↑</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td><strong>TG</strong></td>
<td>←→</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td><strong>Chylo</strong></td>
<td>←→</td>
<td>↑</td>
<td>↑</td>
<td>←→</td>
<td>←→</td>
</tr>
<tr>
<td><strong>CRP / IL-6</strong></td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td>↓</td>
<td></td>
</tr>
</tbody>
</table>
The Balance of IL-1 and IL-1Ra: Key Regulatory Proteins for Innate Immunity

IL-1α
IL-1β

IL-1Ra

IL-1R
IL-1: Potential Roles in Atherogenesis and Methods of Inhibition

Adapted from Fearon W, Fearon D. Circulation 2008;117:2577-9
Application of IL-1β promotes arterial intimal thickening in porcine coronary artery

Shimokawa et al. (1996) J Clin Invest 97:769

Lack of IL-1β decreases severity of atherosclerosis in ApoE-deficient mice

NLRP3 Cryopyrin Inflammasome, Caspase-1, and IL-1β Maturation Endogenous Danger Signals in Vascular Biology?

Pyrophosphate crystals or pathogenic bacteria

Cryopyrin inflammasome

Pyrophosphate crystals

Activation of caspase-1

Cleavage of pro-interleukin-1β

Secretion of mature interleukin-1β

Inflammation

Genetic Determinants of Plasma CRP Level

Dehgman et al, Circulation 2011;123:731-8
Phase transition from soluble to crystalline as an endogenous "danger signal"

Molecular identification of a danger signal that alerts the immune system to dying cells

Yan Shi¹, James E. Evans² & Kenneth L. Rock¹

Phase transition from soluble to crystalline is a "danger" signal

Homeostasis
Uric Acid
40 - 60 μg/ml

Cell death, tissue injury
Uric Acid
> 70 μg/ml
Crystals activate the NLRP3 inflammasome

exogenous particles

Alum \hspace{2cm} Silica \hspace{2cm} Asbestos

endogenous material

Cholesterol \hspace{2cm} Uric acid

Courtesy Eicke Latz  Phase transition from soluble to crystalline as a “danger signal”
NLRP3 inflammasomes are required for atherogenesis and activated by cholesterol crystals

Peter Duewell1,3*, Hajime Kono2*, Katey J. Rayner4,5, Cherilyn M. Sirois1, Gregory Vladimer1, Franz G. Bauernfeind6, George S. Abela8, Luigi Franchi9, Gabriel Nuñez9, Max Schnurr3, Terje Espevik10, Egil Lien1, Katherine A. Fitzgerald1, Kenneth L. Rock2, Kathryn J. Moore4,5, Samuel D. Wright11, Veit Hornung5* & Eicke Latz1,7,10*

Cholesterol Crystals Activate the NLRP3 Inflammasome in Human Macrophages: A Novel Link between Cholesterol Metabolism and Inflammation

Kristiina Rajamäki1*, Jani Lappalainen1, Katariina Öörni1, Elina Välimäki2, Sampsa Matikainen2, Petri T. Kovanen1, Kari K. Eklund1
1 Wihuri Research Institute, Helsinki, Finland, 2 Finnish Institute of Occupational Health, Helsinki, Finland
Cholesterol crystals activate the caspase-1-activating NLRP3 inflammasome to generate IL-1β and initiate atherosclerosis.

Courtesy, George S. Abela, MD.
IL-6 and Risk of Future MI in Apparently Healthy Men

\[ P = 0.01 \]

\[ P = 0.003 \]

\[ P = 0.3 \]

\[ P = 0.001 \]

\[ \leq 1.04 \]

\[ 1.04 - 1.46 \]

\[ 1.47 - 2.28 \]

\[ \geq 2.28 \]

Relative Risk of MI

Quartile of IL-6 (range, pg/dL)

Ridker et al, Circulation 2000;101:1767-1772
Interleukin-6 receptor pathways in coronary heart disease: a collaborative meta-analysis of 82 studies

IL6R Genetics Consortium and Emerging Risk Factors Collaboration

Summary

Background Persistent inflammation has been proposed to contribute to various stages in the pathogenesis of cardiovascular disease. Interleukin-6 receptor (IL6R) signalling propagates downstream inflammation cascades. To assess whether this pathway is causally relevant to coronary heart disease, we studied a functional genetic variant known to affect IL6R signalling.
Canakinumab (Ilaris, Novartis)

- high-affinity human monoclonal anti-human interleukin-1β (IL-1β) antibody currently indicated for the treatment of IL-1β driven inflammatory diseases (Cryopyrin-Associated Period Syndrome [CAPS], Muckle-Wells Syndrome)
- designed to bind to human IL-1β and functionally neutralize the bioactivity of this pro-inflammatory cytokine
- long half-life (4-8 weeks) with CRP and IL-6 reduction for up to 3 months
Effects of Interleukin-1β Inhibition With Canakinumab on Hemoglobin A1c, Lipids, C-Reactive Protein, Interleukin-6, and Fibrinogen

A Phase IIb Randomized, Placebo-Controlled Trial

Paul M Ridker, MD, MPH; Campbell P. Howard, MD; Verena Walter, Dipl Math (FH); Brendan Everett, MD; Peter Libby, MD; Johannes Hensen, MD; Tom Thuren, MD, PhD, on behalf of the CANTOS Pilot Investigative Group

Canakinumab Dose (mg/month)

-64.6%

Ridker PM, et al; Circulation 2012; 126:2739-2748
Stable CAD (post MI)
On Statin, ACE/ARB, BB, ASA
Persistent Elevation of hsCRP (> 2 mg/L)

Randomized
Canakinumab 150 mg
SC q 3 months

Randomized
Canakinumab 300 mg
SC q 3 months

Randomized
Placebo
SC q 3 months

Randomized
Canakinumab 50 mg
SC q 3 months

Primary Endpoint: Nonfatal MI, Nonfatal Stroke, Cardiovascular Death

Secondary Endpoints: Total Mortality, New Onset Diabetes, Other Vascular Events

Exploratory Endpoints: DVT/PE; SVT; hospitalizations for CHF; PCI/CABG; biomarkers

N = 17,200
Novartis
(>6000 currently)
Trying a New Line of Attack in Heart Disease

Two Major Clinical Trials Test If Treating Inflammation Can Cut the Risk of a Heart Attack or Stroke

By Ron Winslow

Two major clinical trials are testing for the first time whether treating inflammation can reduce the risk of a heart attack or stroke, potentially opening up a new line of attack in the battle against cardiovascular disease.

Until now, strategies to fight these killers have focused largely on well-known risk factors such as high blood pressure with anti-inflammatory drugs isn't known.

"This goes beyond simply asking, is inflammation a marker of risk (for cardiovascular disease) to asking if it's a target for therapy," said Paul M. Ridker, director of the center for cardiovascular disease prevention at Harvard-affiliated Brigham and Women's Hospital in Boston, who is leading both trials.

These are especially high-risk patients for whom current optimal treatment often fails. "We've kind of run out of our tool kit for these individuals and yet they're still having events," said Gary Gibbons, director of the NIH's National Heart, Lung and Blood Institute, which officially funded the study.

The Novartis trial, which is testing the company's anti-inflammatory
Two Major Trials to Test Inflammation Hypothesis

By Paul Friedman

Two major clinical trials will test the notion that inflammation causes heart attacks or contributes to the risk of heart disease, the first time that inflammation has been tried as a target for heart attack prevention.

Until now, drugs that block inflammation have been used to treat rheumatoid arthritis and, at much higher doses, certain cancers. But researchers are now recruiting 17,000 patients to test whether they could also lower the risk of heart attacks.

TheNovartis trial is recruiting 17,000 others, about three-quarters of whom will inject different doses of a monoclonal antibody approved for an extremely rare class of inflammatory diseases. Both trials will treat patients for up to 4 years. Novartis has not revealed the cost of its trial, but NHLBI is budgeting nearly $80 million.

“This is testing a whole new paradigm, a whole new approach, towards treating atherosclerosis,” says Michael Lauer, director of the Division of Cardiovascular Sciences at NHLBI. “It’s a really exciting time.”

Ridker is well known among cardiologists for his work on inflammation. He has been a leader in the field of inflammation in cardiovascular disease, and has contributed to the development of new therapies for treating inflammation.

Benefits of the drugs came from targeting inflammation, or from their anticoagulant or antistatic effects, both of which help to lower cholesterol levels. But the drugs are not without side effects, and the trials will be closely monitored for safety.

“Half the world says Paul is wrong, and the other half says Paul is right,” says John Kastel, a vascular medicine specialist at the Academic Medical Center in Amsterdam. “I don’t know which side is right.”

Among them is a paper published in The Lancet in March by a worldwide genetics consortium. The group found that people with a gene variant that blunts interleukin-6 signaling, and thereby reduced sys-
“We await with great interest the outcome of an ongoing trial of the ability of canakinumab, a human monoclonal antibody that neutralizes IL-1β, to reduce CVD in high-risk patients with existing CVD. This placebo controlled study will be a key test of the hypothesis that inhibition of inflammation will be an important new strategy to reduce the burden of CVD.”
"We await with great interest the outcome of an ongoing trial of the ability of canakinumab, a human monoclonal antibody that neutralizes IL-1β, to reduce CVD in high-risk patients with existing CVD. This placebo controlled study will be a key test of the hypothesis that inhibition of inflammation will be an important new strategy to reduce the burden of CVD."

"We await with great interest the outcome of an ongoing trial of the ability of canakinumab, a human monoclonal antibody that neutralizes IL-1β, to reduce CVD in high-risk patients with existing CVD. This placebo controlled study will be a key test of the hypothesis that inhibition of inflammation will be an important new strategy to reduce the burden of CVD."

NIH launches trial to evaluate anti-inflammatory treatment for preventing heart attacks, strokes, and cardiovascular death

The National Heart, Lung, and Blood Institute (NHLBI), a part of the National Institutes of Health, has launched an international multi-site trial to determine whether a common anti-inflammatory drug can reduce heart attacks, strokes, and deaths due to cardiovascular disease in people at high risk for them.
Probiotics, Inflammation, Weight Loss, and Vascular Risk
Primary Prevention of Cardiovascular Disease with a Mediterranean Diet

Ramón Estruch, M.D., Ph.D., Emilio Ros, M.D., Ph.D., Jordi Salas-Salvadó, M.D., Ph.D., Maria-Isabel Covas, D.Pharm., Ph.D., Dolores Corella, D.Pharm., Ph.D., Fernando Arós, M.D., Ph.D., Enrique Gómez-Gracia, M.D., Ph.D., Valentina Ruiz-Gutiérrez, Ph.D., Miquel Fiol, M.D., Ph.D., José Lapetra, M.D., Ph.D., Rosa Maria Lamuela-Raventos, D.Pharm., Ph.D., Lluís Serra-Majem, M.D., Ph.D., Xavier Pintó, M.D., Ph.D., Josep Basora, M.D., Ph.D., Miguel Angel Muñoz, M.D., Ph.D., José V. Sorlí, M.D., Ph.D., José Alfredo Martínez, D.Pharm, M.D., Ph.D., and Miguel Angel Martínez-González, M.D., Ph.D., for the PREDIMED Study Investigators*
Advertisement Campaigns

• $635 million (McDonald’s)
• $298 million (Burger King)
• $224 million (Coca Cola)

Photo courtesy of Randal Thomas
What is translational research? How does an integrated health care system support it?

Bench -> Bedside -> Population

Affiliated Network
Hospitals Clincs

T1, T2, T3
SEROLOGICAL REACTIONS IN PNEUMONIA WITH A NON-PROTEIN SOMATIC FRACTION OF PNEUMOCOCCUS*

By WILLIAM S. TILLETT, M.D., AND THOMAS FRANCIS, Jr., M.D.

(From the Hospital of The Rockefeller Institute for Medical Research)

(Received for publication, June 26, 1930)

It has been shown (1) that pneumococci contain two constituents which are chemically and antigenically distinct. One of these, the type-specific component, is a complex polysaccharide, predominantly present in the capsule of the organism; the other, a substance common to the pneumococcus species, is the so-called nucleoprotein, contained for the most part in the body of the cell. That these two chemically distinct fractions are responsible for the production of two qualitatively different antibodies has been demonstrated (1, 2).

The present report is based upon observations made with a third fraction derived from pneumococci and chemically distinct from both type-specific capsular polysaccharide and non-type-specific somatic nucleoprotein. For purposes of reference this substance is designated Fraction C. The chemical nature of Fraction C and the method of purification together with certain experimental observations are presented in a separate communication (3). In this report it is sufficient to state that Fraction C is a non-protein material of somatic origin and appears to be a carbohydrate common to the pneumococcus species. Although final proof of its exact nature rests upon chemical analysis, nevertheless convincing evidence of the separate identity of Fraction C is brought out by the serological reactions to be described.

Material and Methods

Preparation of Fraction C.—The material employed in the serological tests was derived from a degraded, non-type-specific R strain of Pneumococcus. A strain of this character was employed in order to minimize the presence of type-specific carbohydrate. Fraction C was obtained in the following manner: The organisms

* Presented before the American Society for Clinical Investigation at a meeting held in Atlantic City, May 5, 1930.
Crystallization of CRP

Maclyn McCarty
Oswald Avery, Colin MacLeod
“The Transforming Principle”
Genes are made of DNA
Pentraxin Structure

(NCI* )

Osmond A
Shelton E*
PNAS 1977;
74:739-43
C-REACTIVE PROTEIN IN CORONARY ARTERY DISEASE

Irving G. Kroop*
A STUDY OF C-REACTIVE PROTEIN IN THE SERUM OF PATIENTS WITH CONGESTIVE HEART FAILURE

SAMUEL K. ELSTER, M.D.
EUGENE BRAUNWALD, M.D.
and
HARRISON F. WOOD, M.D.
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From the Departments of Medicine and Microbiology, The Mount Sinai Hospital, New York, Irvington House, Irvington-on-Hudson-New York, and the Department of Pediatrics, New York University College of Medicine.
Received for publication July 27, 1955.
*Rosenstock Foundation Fellow in Medicine.
**Postdoctoral Research Fellow of the National Heart Institute, U.S.P.H.S.

To Paul -
Best wishes

[Signature]

[Signature]
Inflammation, Atherothrombosis, and Vascular Prevention: Three Crucial Questions

Is there evidence that individuals with elevated levels of inflammatory biomarkers are at high vascular risk even when other risk factors are acceptable? Yes

Is there evidence that individuals identified at increased risk due to inflammation benefit from a therapy they otherwise would not have received? Yes

Is there evidence that reducing inflammation per se will reduce vascular events and slow progression of diabetes? CIRT, CANTOS – Let's find out