Vascular Perfusion and The Eye – Brain Connection

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Vascular Perfusion of the Eye

- Age Related Changes in Systemic and Ocular Blood Flow – child vs. adult
- Sensory Retinal Circulation – HRT/F Instrument
- Choroidal Circulation
  - Alon Harris, PhD Canadian Review Article
  - University of Illinois, Vasc. Oxygen Tension
- Pathophysiology of Arteriolarsclerosis
  - Cholesterol Hypothesis in retreat
  - CA ++ Hypothesis in ascendency
- Nutrients for Better Blood Vessels

Blood Flow Stats

- Oxygen consumption
  - whole brain = 46 cm³/min
  - whole brain = 3.3 ml/100 g/min
- Blood flow rate
  - carotid artery = 350 ml/min
  - basilar artery = 100-200 ml/min
- Diameters
  - Vertebral artery = 2-3 mm
  - Common carotid artery (adult) = 6 mm
  - Common carotid artery (newborn) = 2.5 mm

Blood Supply Stats

- % brain utilization of total resting oxygen = 20%
- % blood flow from heart to brain = 15-20%
(Kandel et al., 2000)
- Blood flow
  - whole brain (adult) = 750-1000 ml/min
  - whole brain (adult) = 54 ml/100 g/min
  - whole brain (child) = 105 ml/100 g/min
- Cerebral blood flow
  - average 55 to 60 ml/100 g brain tissue/min
  - gray matter = 75 ml/100 g brain tissue/min
  - white matter = 45 ml/100 g brain tissue/min
The Blood Supply of the Brain

Alon Harris, Ph.D.
Lois Letzter Professor of Ophthalmology
Professor of Cellular and Integrative Physiology

Special Interests
- Ocular hemodynamics in health and disease
- Ocular blood flow in eye disease progression
- Non-invasive imaging assessment of ocular blood flow and metabolism
- Relationship between ocular blood flow and visual function in glaucoma
- Relationship between nerve fiber layer assessment and ocular blood flow in glaucoma
- Vascular etiology of age-related macular degeneration
- Vascular etiology of diabetic retinopathy
- Medications that alter blood flow in age-related macular degeneration and glaucoma
- Assessment of ocular metabolism in health and disease
- Oxymetry, the measurement of oxygen content in the human eye

Ocular Blood Flow Technologies
Harris et al Can J Ophth, 43(3)1-9, June 2008

<table>
<thead>
<tr>
<th>TECHNOLOGY</th>
<th>TISSUE BED</th>
<th>ADVANTAGE</th>
<th>DISADVANTAGE</th>
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</thead>
<tbody>
<tr>
<td>Color Doppler</td>
<td>Retrobulbar BVs</td>
<td>Noninvasive</td>
<td>Measures V, not Flow</td>
</tr>
<tr>
<td>SLO angiography</td>
<td>Retina &amp; Choroid</td>
<td>High Resolution</td>
<td>Measures V not flow</td>
</tr>
<tr>
<td>Canon Laser Flowmetry</td>
<td>Retinal BVs</td>
<td>Measures Flow</td>
<td>Calculated assumptions</td>
</tr>
<tr>
<td>Laser Doppler Flowmetry</td>
<td>Retina &amp; Choroid</td>
<td>Noninvasive</td>
<td>Difficult to interpret</td>
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<tr>
<td>Confocal SL Doppler</td>
<td>Retinal Capillaries</td>
<td>Measures Flow</td>
<td>Flow in arbitrary units</td>
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<tr>
<td>Retinal oximetry</td>
<td>Retinal Vessels &amp; Tissues</td>
<td>Metabolism Assessment</td>
<td>Not validated</td>
</tr>
<tr>
<td>Pulsatile Ocular Blood Flow</td>
<td>IOP Pulse Amp</td>
<td>Inexpensive &amp; easy to use</td>
<td>Calculated assumptions</td>
</tr>
<tr>
<td>Retinal V Analyzer</td>
<td>Large Ret Vessels</td>
<td>High Resolution</td>
<td>Difficult to interpret</td>
</tr>
</tbody>
</table>

....both NTG & POAG

- ↓ retinal blood flow
- ↓ choroidal blood flow
- ↓ retrobulbar blood flow
- Dysfunctional auto-regulation
  - *** taken together, implies ↓ blood flow to the retinal ganglion cells and the optic nerve.
Relationship of cerebral blood flow and central visual function in primary open-angle glaucoma.
J Glaucoma. 2007 Jan;16(1):159-63. Harris A et al.,

• PURPOSE: To investigate the relations between middle cerebral artery (MCA) blood flow velocities and central visual function measured by foveal cone electroretinograms (ERG) and visual field.
• METHODS: 15 COAG. The eye with the more severe visual field defect (full threshold 24-2) and/or optic disc damage was chosen. Brachial arterial pressure, heart rate, visual acuity (logMAR), contrast sensitivity (CST-1000), central visual field (Humphrey SITA 10-2), foveal cone ERG, and transcranial Doppler. Pearson correlation coefficients were estimated to assess the strength of the linear relationship between the MCA flow velocity and the other measured parameters.
• RESULTS – see Table next slide:
• CONCLUSIONS: "In certain primary open-angle glaucoma patients diminished central visual function may be one manifestation of widespread cerebrovascular insufficiency".

<table>
<thead>
<tr>
<th>Vasc Parameter</th>
<th>Pearson r</th>
<th>P value</th>
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<tbody>
<tr>
<td>Focal cone ERG (amplitude)</td>
<td>r = 0.69</td>
<td>P = 0.009</td>
</tr>
<tr>
<td>Foveal cone ERG (implicit t)</td>
<td>r = 0.011</td>
<td>ns</td>
</tr>
<tr>
<td>Mean VF central sensitivity</td>
<td>r = 0.76</td>
<td>P = 0.005</td>
</tr>
<tr>
<td>Mean defect</td>
<td>r = 0.73</td>
<td>P = 0.007</td>
</tr>
<tr>
<td>LogMAR VA</td>
<td>r = 0.57</td>
<td>P = 0.04</td>
</tr>
<tr>
<td>CSF</td>
<td>r = 0.61</td>
<td>P = 0.03</td>
</tr>
</tbody>
</table>

Performance of Colour Doppler imaging discriminating normal tension glaucoma from healthy eyes.
Plange N et al Eye. 2007 Aug 10

Design Prospective cross-sectional institutional study
Methods n = 62 untreated NTG (mean age 57±14 years)
    n = 40 age-matched controls (mean age 58±9 years) were included in a Peak systolic velocity (PSV), end-diastolic velocity (EDV), and resistive indices (RI=EDV/PSV) of the ophthalmic artery (OA), central retinal artery (CRA), and short posterior ciliary arteries (PCAs) were measured by means of CDI.
Using receiver operating characteristic (ROC) curves, sensitivity was determined at 90% specificity.
Results Patients with NTG showed significantly decreased PSV (P<0.0001) and EDV (P<0.0001) of the CRA, significantly decreased EDV of the nasal (P=0.004) and temporal (P=0.002) PCA, and significantly increased RI of the temporal (P=0.003) PCAs compared to healthy controls. Sensitivity values at 90% specificity were calculated: PSV of the CRA, 30.6%; EDV of the CRA, 48.4%; EDV of the nasal PCA, 43.9%; EDV of the temporal PCA, 45.9%; and RI of the temporal PCA, 39.3%.
Conclusions The power to identify NTG using CDI reaches 48% sensitivity at 90% specificity. Further longitudinal studies are needed to determine the prognostic value of CDI in.

The Zeaxanthin & Visual Function (ZVF) Study

Sensory HRT/F Blood Flow and Self Assessed Health in AMD

This ZVF AMD population has less than ideal self-assessed health and driving difficulty. Note that these patients in general, are at less risk for catastrophic vision loss than high risk AREDS and AREDS II AMD patients, and have excellent visual acuity. There was a weak correlation (r = 0.33) of global VFQ25 scores and driving subscale VFQ25 scores with foveal MP (r = 0.38), but no relationship with overall health (r = -0.15).
CVD and AMD share many common risk factors

- "sick eyes may occur in sick bodies related to smoking, obesity, inadequate nutrient intake, and other unhealthy behaviors".


AMD means ↓ Choroidal Vascular perfusion

**WET**

- n=11, age 75 w subfoveal CNVM
- Confocal laser doppler measured blood flow 300 u behind fovea
- "The eye with CNVM had a Confocal Laser Doppler Flow significantly reduced by 35 % +/- 389 % sd (p=0.02; paired T) compared to normal fellow eye.

**DRY**

- n=25 controls; n=25 AMD
- Color Doppler imaging post ciliary artery
- 18-26 % decreased peak systolic velocity
- 8-18 % decreased end systolic velocity
- In ICGA AREA DILUTION ANALYSIS, 10% & 63 % filling times delayed

HRT / F

HRT II confocal scanning laser with a color doppler flowmeter
**Disadvantage:**
Provides relative volume and flow, not absolute #s.

2560u x 640u x 400u deep images +/- 10u  
790nm laser samples @4000 HZ  
Fast Fourier Transform to extract the point-by-point Doppler Frequency shift of reflected light  
Default 100u x 100u region of tissue

**Heidelberg Retinal Flowmeter is reproducible**

Baseline ZVF Retinal Blood Flow Data; Average Blood Flow OD vs OS

...and average sensory retinal blood flow between eyes is also highly correlated ($r = 0.59$)
Average sensory retinal blood flow in the worst functioning eye is compared to that in the better functioning eye is highly correlated ($r = 0.58$).

**STROKE & SOCIOECONOMIC STATUS**

- The American Heart Association estimates that stroke, "the third leading cause of death in the United States, strikes some 780,000 people annually," and that "about 27 percent of strokes occur in people under age 65."
- Wealth and high income may reduce stroke risk among Americans 50-64. Participants in the lowest category for wealth (less than $1,000) and annual income ($5,657) had a relative stroke risk of 2.3 and 1.8, respectively, compared with participants in the highest category ($344,499 or more and $56,993 a year or more).

**Plaque – 3% Cholesterol but 50% CA++**

- Circulus arteriosus (WILLIS)
  1. A.carotis interna
  2. A.vertebralis
  3. A.basilaris
  4. A.cerebri anterior
  5. A.cerebri media
  6. A.cerebri posterior
  7. A.communicans anterior
  8. A.communicans posterior
  9. A.superior cerebelli
  10. A.inferior anterior cerebelli
  11. A.inferior posterior cerebelli

Detail:
red:Aa.centrales anterolaterales
The CA++ Overload Hypothesis

- British cardiologist Stephen Seely noted that countries which consume the highest amount of CA++ (New Zealand, Ireland, North America, Scandinavian countries), mostly from dairy products, have the highest rates of cardiovascular disease. [International Journal Cardiology 1991 Nov; 35(2):191-8]

Postmenopausal women who take CA++ supplements increase their risk for a heart attack by about 45%. [British Medical Journal 2008 Feb 2; 336 (7638): 262-6]

  - N= 6722 men and women, ~age 60 w/o CAD
  - Studied for 3.8 years (median).
  - Adverse coronary events (heart attack, angina, placement of a stent, coronary death) (~28%) were taking cholesterol-lowering drugs Vs. (~16%) who did not experience such an event.
  - MI or angina had the same total cholesterol (~199 mg%) as subjects who did not (~194 mg%).
  - Cholesterol barely met statistical significance whereas CA++ was highly predictive.

The predictive power of CA++

- Among subjects whose coronary artery CA++ score was zero, the risk for any adverse coronary event was only about one-half of 1% (0.0044), or less than 1 in 200.
- Those with a coronary CA++ score over 300, about 8.0% experienced an adverse event involving coronary arteries (0.0804), or about 8 in 100, an 18-fold difference (1800%), over the 3.8 year period.

- Arterial CA++
  - 64 cut CT scan (called an Agatston score, for Dr. Arthur Agatston, South Beach Miami, Florida cardiologist).
  - CA++ scores greater than zero*:  
    - 70% of white males
    - 52% of black males
    - 57% of Hispanic males
    - 59% of Chinese males
  - Among older men (84-96 yrs), risk for death was 48.6 per 1000 person-years with a high CA++ artery score (over 1000 Agatston score), but there were no deaths (zero!) when the CA++ artery score was less than 10. [J Am Geriatric Assn 455: 1948-54, December, 2007]

Among 1726 middle-aged adults (~ age 57 years) who had no cardiac symptoms, those who died of heart disease or experienced a heart attack had, on average, a higher CA++ artery score (448) than those who did not (206). Subjects with the highest CA++ artery score were twice as likely to die (2.2 vs. 0.9) than subjects with the lowest CA++ artery scores.

No heart attacks or cardiac deaths were observed among patients with no coronary artery CA++.

A long-term moderate magnesium-deficient diet aggravates cardiovascular risks associated with aging and increases mortality in rats.


Adrian M, Chanut E, Laurent P, Gaume V, Berthelot A

"Metabolic and cellular optimisation", Université de Franche-Comté, UFR Sciences Médicales et Pharmaceutiques, Besançon, France bLaboratoire de Pharmacologie, Faculté de Pharmacie Paris XI, Chatenay-Malabry, France.

- **OBJECTIVE:** The present study aimed to show whether long-term moderate magnesium (Mg)-deficient (150 mg/kg) and Mg-supplemented (3200 mg/kg) diets (versus control diet: 800 mg/kg), modified the occurrence of cardiovascular risk induced by aging in the rat.
- **CONCLUSION:** It is suggested that a long-term and moderate Mg-deficient diet increases age-induced arterial thickness and stiffness in rats, and thus increases the cardiovascular risks incurred by aging.

Heart Disease Lurks in Obese Americans

**Obesity Linked to Troubling Signs of Future Heart Disease**

May 12, 2008 – Archives of internal Medicine

Wake Forest University researcher Gregory L. Burke, MD, and colleagues studied nearly 7,000 people enrolled in the Multi-Ethnic Study of Atherosclerosis (MESA) trial who were free of heart disease at the beginning of the study.

Researchers evaluated patients for the presence of traditional risk factors such as weight, high LDL cholesterol levels, high blood pressure, and diabetes. They also looked for signs of sub-clinical heart disease, such as calcium buildup in heart arteries, narrowing of the carotid arteries, and increased heart muscle mass.

Compared to normal-weight people who had the same traditional risk factors for heart disease, obese people had more advanced signs of sub-clinical heart disease. Obese individuals displayed higher rates of CA++ buildup in their heart arteries, more narrowing of their carotid arteries, and higher measurements of heart muscle mass. All of these indicators suggest a higher risk of cardiac events in the future.

GNC Calcium Plus with Magnesium & Vitamin D #143111

180 Capsules

regular Price: $11.99
Nutrients for better blood Vessels

- Vitamin C/E and lysine
- Bioflavanoids
  - 4 ounces frozen berries / day
  - 2 ounces pomegranate juice / day
- B Vitamins
- Magnesium
- Omega III and FlaxSeed (omega III & IP6)
- Rice Bran:
  - IP6 CA++ & Fe++ chelating agents
- Vitamin D and K
- Arginine
- Condrointin Sulfate
- Resveratrol

Vitamins C & E - Atherosclerosis

Schematic representation of antioxidant actions. Incorporation of antioxidants into low density lipoprotein (LDL) protects LDL oxidation. Additionally, the incorporation of antioxidants into vascular cells may protect against vascular cell oxidation of LDL, thereby preventing the vascular response to oxidized LDL. (Reproduced with permission from Díaz, FN, Frai, B, Vita, JA, et al. N Engl J Med 1997, 337:405.)

Parallels

Coronary, carotid and retinal angiography

Veterinarians know “Cavies should receive between 25-50mg of vitamin C daily” Fresh fruits and vegetables high in vitamin C are a great source

1 kg guinea pig

70 kg human equivalent is 1,750 mg to 3,500 mg / day

Maybe that's why we need those 13 portions of fruits and vegetables per day, The average American consumes only 3 portions.
CardioRetinometry™
Dr. Sydney J Bush, PhD, DOpt. (IOSc. London)
Bushopticians.com


Contact lens patients placed on 3,000-10,000 mg vitamin C per day.

First retinal vessel differences noted late 1999 early 2000.

BEFORE AFTER
Retinal photograph taken in 2002 (left) reveals artery disease (vessel narrowing, drop out of some vessels). Retinal photo (right) taken in 2004 after daily vitamin C supplementation confirms retinal arteries have widened and some reappear.

Dr. Bush, a Contact lens and Primary care optometrist believes that if every adult took time released Vitamin C, or frequent doses of Vitamin C, the mortality rate would drop significantly.
Vitamin C and Nuclear Cataract


Coronary Heart Disease
Age-Adjusted Death Rates: Actual and Expected
United States, 1950-2000

C/E Randomized Control Trials

The Antioxidant Supplementation in Atherosclerosis Prevention (ASAP) Study
- Vits. C & E: 500 mg; 182 mg
Harvard Intravascular Ultrasonography (IVUS) Study
- Vits. C & E: 1000 mg; 536 mg
HDL-Atherosclerosis Treatment Study (HATS)
- Vits. C & E: 1000 mg; 536 mg
- Multi-Vitamins and Probucol (MVP) Study
  - Restenosis s/p balloon angioplasty; Vit C, E, & β-carotene- 500 mg, 700 IU (637 mg), 30000 IU
- Heart Protection Study
  - Mortality; Vit C, E & β-carotene- 250 mg, 600 mg, 20 mg

- Vitamin E
- Maximum now 100-200 IU of a mixture of the natural Vitamin E (tocopherols & tocotrienols)
- Higher doses theoretically may interfere with ASA or Coumadin therapy
Vitamin C (F&V) Protects The Brain Against Stroke
(EPIC-Norfolk study, *Am J Clin Nutr.* 2008;87:5-7, 64-69)

- 1 city in the UK, n=20,649, ages 40-79 w/o evidence of CVA over 9.5 years
- Quartiles of plasma vitamin C drawn
- CVA incidence from death certificates
- Compared with subjects in the lowest quartile of plasma vitamin C concentration, participants in the top quartile had a 42% relative risk reduction for stroke (*P=0.001*). This result remained significant after adjustment for multiple confounders.
- Vitamin C concentration appeared to have a linear negative relationship with the risk for stroke. For every 20-µmol/L increase in the level of vitamin C (approximately equivalent to the addition of 1 serving of fruit or vegetables per day), there was a 17% reduction in the risk for stroke.

<table>
<thead>
<tr>
<th>Quartile, µmol/L</th>
<th>Relative Risk</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quartile 1 (&lt; 41)</td>
<td>1.00 (Reference)</td>
<td>—</td>
</tr>
<tr>
<td>Quartile 2 (41 - 53)</td>
<td>0.84</td>
<td>0.66 - 1.07</td>
</tr>
<tr>
<td>Quartile 3 (54 - 65)</td>
<td>0.64</td>
<td>0.48 - 0.84</td>
</tr>
<tr>
<td>Quartile 4 (&gt; 66)</td>
<td>0.58</td>
<td>0.43 - 0.78</td>
</tr>
</tbody>
</table>

*CI indicates confidence interval.

PureWay C

Check out the latest product in vitamin C supplementation—Swanson PureWay-C 500 mg with Bioflavonoids. This new form of vitamin C is different than all previous forms because it employs naturally derived lipid metabolites, from vegetable waxes, to enhance the uptake, distribution and release kinetics of ascorbic acid. PureWay-C uses lipid metabolism to alter the lipid absorption potential of generally water-soluble ascorbic acid, thereby enhancing the vitamin’s bioavailability unlike any other formulation. Lipid metabolites interact with cells in a non-toxic, safe and effective manner to enhance bioavailability of ascorbic acid. Plus, it’s scientifically proven to scavenge up to 93% of free radicals! PureWay-C has independent research to support its superior health benefits to nervous system, skin and immune system health. Make the switch to PureWay-C today!

Scientific Research

Comparative research studies in vitro and in humans demonstrate that Pureway-C® is more rapidly absorbed and leads to higher plasma and cellular levels, having faster and more beneficial effects than ascorbic acid, calcium ascorbate and other ascorbate brands. These benefits include better stimulation of neurite outgrowth, reduced fibroblast wound healing activities, increased protection of the immune system from xenobiotic induced inflammatory mechanisms, and greater reduction of plasma levels of C-reactive protein and oxidized LDL as well as more potent antioxidant and higher free radical scavenging capabilities.*


http://www.innlabs.com/purewayc.html
Vitamin C formulations enhance NGF-mediated neurite outgrowth. PC12 cells were treated with 100 ng/ml of NGF and incubated for a 24 hour period and then these cells either received no further treatment, or were treated with 0.5 \( \mu \)M Ascorbic acid, Calcium ascorbate, PureWay-C® or other ascorbate brands. After these treatments, the cells were incubated over a 24 hour period during which the formation of neurites was assessed at hours 1, 3, 6, 9, 12 and 24. Med Sci Monit 2007; 13(3): BR51-58

Vitamin C formulations reduce phytohemagglutinin (PHA) induced T-cell aggregation. Human H9 CD4+ T-cells were treated with phytohemagglutinin (PHA) and then either given no further treatments (PHA) or treated further with 0.5\( \mu \)M Ascorbic acid, Calcium ascorbate, PureWay-C® or other ascorbate brands. The cells were then incubated for 30 minutes and the number of cells per aggregate was determined. Med Sci Monit 2007; 13(3): BR51-58

Scavenging activity for free radicals of 1,1-diphenyl-2-picryl hydrazyl (DPPH) has been used to evaluate the antioxidant activity of natural products. DPPH is a stable free radical with purple color, the intensity of which is measured at 510nm spectrophotometrically. Antioxidants reduces DPPH to 1,1-diphenyl-2-pircryl hydrazine, a colourless compound. In summary, these data confirm and show that PureWay-C® may dose-dependently and significantly inhibit free radicals. Dietary or supplemental PureWay-C® may provide efficient antioxidant protection to humans and animals from all these oxidation products or processes of oxidation that contribute to the pathogenesis of cancer, cardiovascular diseases, and other age-related diseases by citotoxic, genotoxic and proinflammatory mechanism and atherosclerosis.

Emerging Biomarkers....

<table>
<thead>
<tr>
<th></th>
<th>Homocysteine umol/L</th>
<th>Flavonoids Mg/d</th>
<th>Vitamin E Ug/l</th>
<th>Omega 3 % CE fraction</th>
</tr>
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<tbody>
<tr>
<td>8</td>
<td>101</td>
<td>16.8</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>13</td>
<td>12.6</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

BJ Wilcox, DC Wilcox, H Todoriki, M Suzuki, JAGS, 2001
Case Report: Scheie Retinal 3 Changes

- 44 AA female, 3rd youngest of 11 siblings (5 females), Iraq War Vet
- Raynaud’s Phenomenon
- Arthralgia
- IBS

- FmHx: Male family member CVDz Hx at young age (2 brothers and father) in 30s and 40s had heart attacks.

Cardiovascular Biomarkers in Okinawans vs. Americans

<table>
<thead>
<tr>
<th></th>
<th>HTN %</th>
<th>Cholesterol</th>
<th>BMI&gt;25</th>
<th>Diabetes %</th>
</tr>
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<tbody>
<tr>
<td>Okinawan centenarians</td>
<td>1.5</td>
<td>152 total 49.8 HDL Ratio 3.1</td>
<td>&lt;1 %</td>
<td>1 %</td>
</tr>
<tr>
<td>Okinawan elders</td>
<td>37</td>
<td>212 total 57.5 HDL Ratio 3.7</td>
<td>26 %</td>
<td>8 %</td>
</tr>
<tr>
<td>US Elders</td>
<td>61</td>
<td>221 total 37 HDL Ratio 6.0</td>
<td>64 %</td>
<td>12 %</td>
</tr>
</tbody>
</table>

BJ Wilcox, DC Wilcox M Suzuki, Circulation 2003, Japan National Health Survey 1990-2000 vs. NHANES III

Vitals

- T 97, P 85, R 16
- BMI = 27
- BP: 111/72; 111/70; 139/83 (1/08-4/08)
- Chol = 242; LDL = 142; HDL = 89
- Takes 40 mg statin drug

45 degree Retinal Images
### Lab Results

<table>
<thead>
<tr>
<th>Test Name</th>
<th>Result</th>
<th>Units</th>
<th>Range</th>
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</thead>
<tbody>
<tr>
<td>HOMOCYSTEINE</td>
<td>21.3 H</td>
<td>umol/L</td>
<td>0-15.0</td>
</tr>
<tr>
<td>C-REACTIVE PROTEIN</td>
<td>&lt;0.2</td>
<td>mg/dL</td>
<td>0.0-0.9</td>
</tr>
<tr>
<td>LIPOPROTEIN LP(a)</td>
<td>287.4 H</td>
<td>mg/dL</td>
<td>0-60</td>
</tr>
</tbody>
</table>

Comments: Collection time: Mar 07, 2008@15:50:11

### Treatment

- Before lab tests
  - 2 g Cod liver oil and multivitamin w minerals
  - 1000IU vitamin D daily
- add fruit consumption-- now totally devoid
- start 500mg ascorbic acid TID po
- Vitamin C 500 mg TID
- B Complex vitamins (B6, B12 and folic acid)