ATHEROSCLEROSIS:
The link between sugar, stress, high cholesterol, and the formation of atheromas.

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Introduction

My friend was recently diagnosed with high cholesterol. She was baffled, and could not believe the diagnosis. Her physician is giving her three months to lower the levels herself and if it does not lower, he said she needs cholesterol medication. Besides the financial implications, there is the fear of being on a medication for life. She asked me, "You know what I eat, how can this be?" Before my most recent biomedicine class with Dr Allison Bachlet I would have been equally baffled. My friend does not eat high-fat or greasy foods. In fact, she barely eats. Then I began to think about what, when, and how she eats. Taking the lessons from class on the formation of cholesterol plaques in arteries, everything made sense. The cholesterol levels indicated a high level of arterial damage from a stressful life and a high sugar and caffeine intake. There are critical questions that were missing in the interaction between her and her physician: what in my diet and life could have caused this, and what can I do to change my life to be healthy?

My friend is a professional woman, constantly on the go, working long hours at a stressful job, and does not make much time for herself. She grabs a cup of coffee with artificial sweetener and sometimes an egg sandwich for breakfast, scarfs down a salad at lunch in record time, grabs a candy bar and coffee to keep her going through the mid-afternoon squeeze, and barely gives dinner a thought after a long, tiring day. This sounds like the typical over-worked, over-stressed, career/finance-focused American. And she, like 100 million other Americans, was diagnosed with high cholesterol. Her likely future: a life-sentence of doctor visits, cholesterol medication, side-effects, and a decreasing bank account. This course exemplifies the life and future of many Americans. What can be done? My answer: holistic health care with attention focused on the patient, proper education, and lifestyle changes.

American physicians are not always proactive in making lifestyle and nutrition changes, but they all have the education to do so. What would make a difference? Where can the physician and patient meet in the goal of true health? Attention to detail, education, and commitment. What if physicians took time to examine the lifestyle of the patient, including eating habits, daily routine, mental and emotional health, relationships, acute and chronic stress, and health goals? What if each physician stepped outside the normal habits of being the typical, stressed American rushed by a finance-focused administration allotting only 10-15 minutes per patient, and instead take 20-30 minutes to get to know their patients and work on a proper diagnosis and treatment strategy? What if each patient were properly educated about the function of the body and proper nutrition and totally committed to their health? The health of Americans and our nation as a whole would alter significantly.

There is valid concern: 100 million Americans are diagnosed with borderline to high cholesterol. Annually, 800,000 thousand Americans die from heart disease, stroke, and cardiovascular diseases. Despite the abundance of education on the topic, many Americans are surprised and confused on their diagnosis. Many report eating a seemingly low-cholesterol diet and being physically active. Many undergo drastic diet changes including consuming artificial, low-calorie, low-fat food. Many are prescribed cholesterol-regulating medication; Lipitor, the leading cholesterol medication is a $10.7 billion dollar industry. Seemingly, the education is there, the foods are there, the medication is there. Why is high cholesterol still such a significant problem; it does not fit?

There are missing links in education in regards to the functionality of cholesterol, its LDL and HDL companions, and lifestyle factors that cause an increase in blood cholesterol levels. These missing

links are sugar and stress, and improper education. This paper focuses on the contribution sugar and stress have on high cholesterol and atherosclerosis formation from a Western and Traditional Chinese Medicine (TCM) view, as well as the need for proper education and treatment.

Importance of Cholesterol

Cholesterol is a waxy, fat-like substance found in all cells of the body. Cholesterol is made in the liver and is also found in some of the foods we eat. [1] It is responsible for providing cell structural support, preserving the water-resistant skin barrier, and conducting nervous impulses. It is needed to make hormones such as testosterone, estrogen, progesterone, aldosterone, and cortisone. Without aldosterone your body cannot regulate water and sodium levels. Without cortisone your body cannot cope with stress; this is an important factor that will come up later. [13] Together with sun exposure, cholesterol is required to produce vitamin D. It is also needed to synthesize bile acids that help digest fat and absorb vitamins. [2,10,13] Without a doubt, cholesterol is needed in the body to function. There are various schools of thought on the role of cholesterol and the problems that it can cause; however, many do not look at the function of cholesterol. Functionally, cholesterol is part of an immune reaction to a need for healing in the body and making it run efficiently.

"Good" and "Bad" Cholesterol

Cholesterol is water-insoluble and thus, must be transported inside lipoproteins. The two types of lipoproteins most abundant in the body are low-density lipoprotein (LDL), and high-density lipoprotein (HDL). LDL is commonly known as the "bad cholesterol." The function of LDL is to transport cholesterol from the liver to the tissues to repair cell membranes. [13] LDL is often acknowledged for forming plaques and causing artery damage. HDL is commonly knows as the "good/protective cholesterol." The function of HDL is to collect and deliver old cholesterol for use or excretion. The HDL transports cholesterol to steroid-producing organs such as the adrenal glands, testes, and ovaries to make hormones as well as to the liver to be excreted into bile for the absorption of fats. [3,7,9]

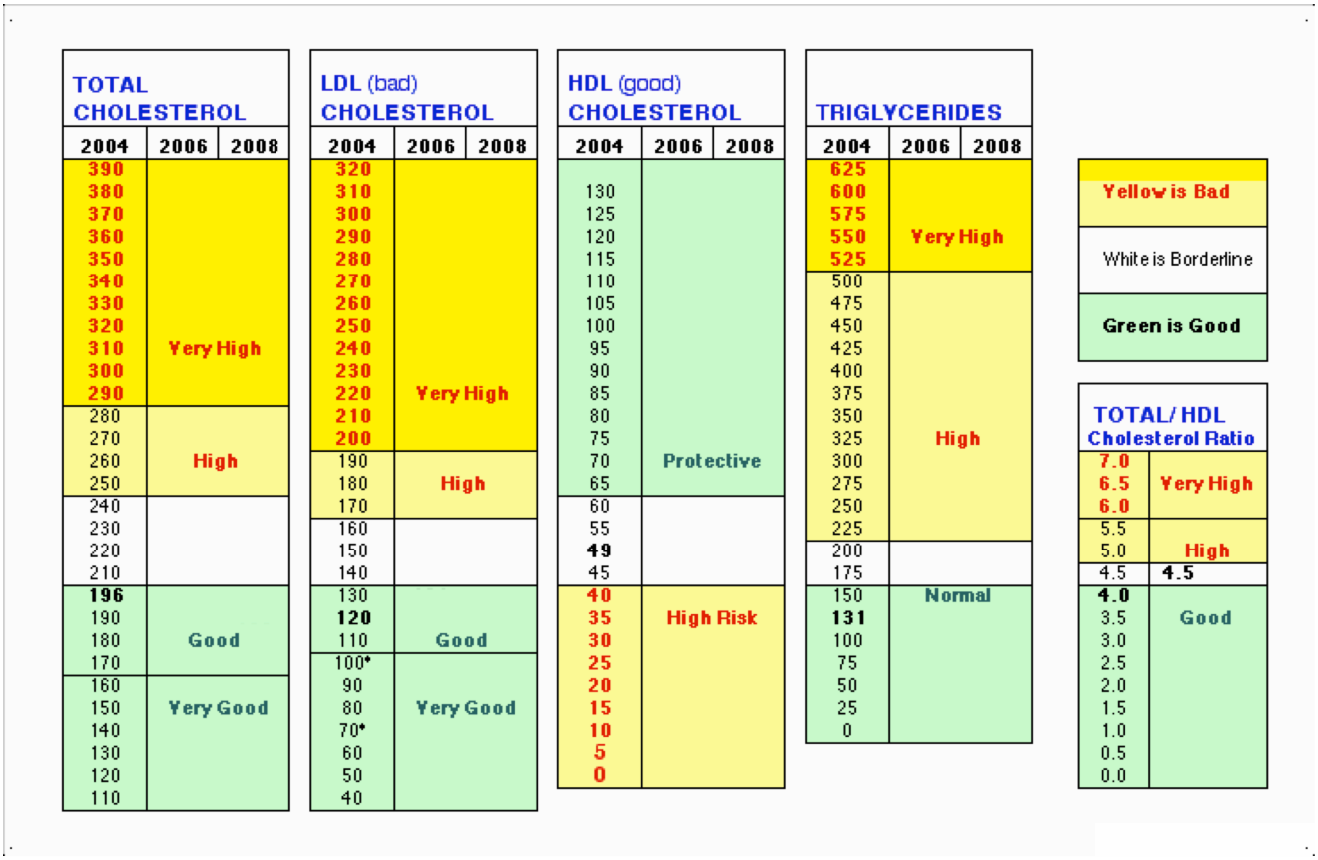
While both lipoproteins serve an important function in the body, most medical websites and educational information support the "good/bad" cholesterol hypothesis. Because high levels of LDL cholesterol are seen as a risk factor for heart disease, it is the main focus of cholesterol-lowering treatment.

Cholesterol Numbers

Four serum tests are used to diagnose cholesterol levels: total cholesterol, LDL, HDL, and triglycerides. Total cholesterol is measured as milligrams (mg) of cholesterol per deciliter (dL) of blood. High cholesterol is categorized as 240 mg/dL and above, borderline high is 200-239 mg/dL, and desirable is less than 200 mg/dL. [1] The best level of LDL for most people is below 130 mg/dL. If there are risk factors for heart disease, the target LDL is below 100 mg/dL. If a person is at very high risk of heart disease, the target LDL is below 70 mg/dL. In general, the lower your LDL cholesterol level is, the better. The optimal levels for HDL are 60 mg/dL and above. Anything less than 40 mg/dL in men and 50 mg/dL in women is considered high risk for heart disease. [7] In the above *JAMA* study, the group of participants deriving ≥25% of calories from added sugars had HDL levels of 47.7 mg/dL,

which is on the border of heart attack risk. Figure 1 highlights the various cholesterol levels. [5]

Fig. 1:



Cholesterol Fear Factor

"There are 100 million Americans with cholesterol levels over 200 mg/dL" [8] states Dr Vince Bufalino president and CEO of Midwest Heart Specialists in Chicago and American Heart Association (AHA) spokesperson. More than 800,000 adult deaths from heart disease, stroke, and other cardiovascular diseases. Bufalino states that many people are not treated for high cholesterol and are given a chance with diet and exercise to lower cholesterol themselves. Recommendations include exercise, eating nutritious foods, and lowering consumption of foods high in saturated fat and cholesterol including red meat, dairy products, eggs, and fried foods. Bufalino states that elevated cholesterol levels can lead to heart attack and strokes, and doctors want to treat patients early and keep their levels controlled.

A *NY Times* article on atherosclerosis states that key measures to maintain cholesterol levels include a "heart healthy diet, exercise, and medications." [12] The Center for Disease Control and Prevention (CDC) links heart disease to a lack of medical accessibility. It states that many people lack access to medical care, prescriptions, or lifestyle counseling to ensure proper medical care. People do not make follow up appointments to regulate cholesterol and one in two adults stop taking cholesterol medication.[8] The National Heart Lung and Blood Institute states that saturated fat raises the LDL levels "more than anything else in your diet." [1] WebMD warns that "inside the artery wall, free

radicals transform LDL from something bad to something worse." The web article likens the functionality of LDL to a "cholesterol chemical spill" while displaying ads from Lipitor all over the page. [3] For millions of Americans, this is the reality of what they are taught about cholesterol. Fear the "bad," increase the "good," radically change your diet, and take medication. The public needs access to thoughtful medical and health education that is not sponsored by drug companies.

Atherosclerosis Plaque Formation, Western Medicine View

The common perception is that "bad" LDL cholesterol adheres to the artery walls, forms a plaque, clogs arteries, and leads to heart disease, a stroke or heart attack. [3] Functionally, the LDL involvement in atherosclerosis is an inflammatory process that begins with a tear in the artery wall between the inner and outer layers. Tears can be caused from a variety of dietary and lifestyle processes, including: free-radicals and pollutants from cigarette smoking, sugar, alcohol, overcooked protein, auto/diesel exhaust; homocysteine; psychological stress; microbial infection; excessive omega-6 fatty acid intake; inadequate omega-3 fat intake; inadequate vitamin C intake; inadequate vitamin E intake; inadequate vitamin B6 from overconsumption of protein; and, pain medications. [10,13] All of these factors have been shown to exert an atherogenic effect, unrelated to elevated serum cholesterol. [10]

Damage and tears to the artery wall triggers an immune inflammatory process to repair the injury. [10] The damaged endothelium secretes chemo-kines to attract and bind monocytes. These monocytes differentiate into macrophages that protect the area from infection by engulfing and disposing of any foreign objects. [13] LDL cholesterol attaches to the wound, is engulfed by macrophages and crosses the endothelium layer becoming oxidized, foam cells. [4,15,16] Calcium is deposited and the artery lining hardens. Over time, and with increased damage to the endothelium, large plaques form and impede blood flow. An accumulation of cholesterol in the blood and the hardening of the arteries (atherosclerosis) that accompanies this buildup narrows the space that blood can flow through. Over time, the function of the artery will diminish and blood supply to the heart will decrease. [2] High cholesterol is factor in cardiovascular disease, its presence indicates a potential for strokes and heart attack. The vascular inflammatory process demonstrates that LDL "bad" cholesterol is not the *cause* of high cholesterol, but a *factor* in the process. High levels of LDL cholesterol can be a good indicator of artery damage and a signal to change lifestyle habits.

Atherosclerosis, Traditional Chinese Medicine View

In TCM, atherosclerosis involves several factors: inflammation and internal heat, drying of fluids and vessel walls, and accumulation of dampness (lipids) in the blood from the body trying to cool off the blood. Inflammation is a process of heat being created in the body from daily moderate repression of emotion, involving an internal conflict. [17] Heat can be due to an overactive nervous system from the emotions of anxiety, worry, obsession, and emotional shock. It involves two opposing forces: an "irresistible force" of active energy and an "immovable object" of repression which creates stagnation. Slow-building anger and resentment that is not expressed directly can turn to rage. There are other lifestyle habits that can create heat, including caffeine, and recreational stimulants such as cocaine and amphetamines. Overwork and excess exercise can tire out the Liver and the blood that store it, creating stagnation. This stagnant energy generates heat. The function of the Liver is to store blood, thus the heated blood accumulates in the Liver and then eventually works its way through the

circulatory system and causes inflammation of the blood vessels. The heated blood expands against the vessels and causes them to distend and become weak.

Simultaneously, the body tries to cool off the system with the yin fluids from the Kidney. Continual need for yin fluids leads to depletion of yin and the body becomes dry. The vicious cycle of generating heat and needing to cool off the blood by using fluids causes more fluids to be used which makes the nerves irritable, creating more heat and needing more fluids. [17] Blood vessels lose their flexibility and begin to harden. As a result, the body begins to patch up the vessels with cholesterol and plaques form, creating atherosclerosis. Repeated attempts to cool the blood off drain the yin fluids and do not allow the Kidney to mist and cool off the Heart, causing Heart deficiency and high blood pressure. The causal link between emotions and atherosclerosis is visible.

Stress and High Cholesterol

The link between emotions, overwork, and the body's vascular inflammatory response is highlighted. The next move is to look at what people do when they are overstressed. Often times, they consume sugar, fat, and salt. [18] The stress hormone, cortisol, promotes abdominal fat and may be the major reason people who are stressed gain weight. [18] Returning to the section “importance of cholesterol,” both cortisone and cortisol are end products of hormone/steroid synthesis of cholesterol. Cortisol is a steroid hormone released in response to stress. If a person has an increase in cortisol, it is expected that they are also having an increase in stress, and potentially an increase in cholesterol. With 100 million Americans diagnosed with high cholesterol, the question arises of how stressed the average American feels?

The annual survey “Stress in America,” conducted by Harris Interactive in conjunction with the American Psychological Association, reports that 75% of Americans suffer from unhealthy levels of stress. [19] 1,134 adults aged 18+ and 1,136 young people aged 8-17 were surveyed. The survey focused on stress, relationships, employment, family life, physical activity, eating habits, and obesity. The most notable results showed the connection between overweight children and stress. Thirty one percent (31%) of overweight children report that they “worry a lot or a great deal about things in their lives.” This is compared to 14% of children of normal weight. Parents of overweight children are less likely to eat healthy foods (14% vs 26%). Parents of normal weight are more likely to engage in physical activity with their families (69% vs 53%). Children who are overweight are more likely to feel angry or get into fights (22% vs 13%). Children who are overweight are more likely to eat too much or too little (48% vs 16%). Children who are overweight are more likely to eat to make themselves feel better when they are stressed (27% vs 14%). High cholesterol, high blood pressure, and obesity were the most common health conditions, averaging 30% across the board. The most common physical symptoms of stress reported were irritability (45%), fatigue (41%), and lack of energy/motivation (38%). These can be translated into TCM of Liver Qi stagnation, Heart blood and/or yin deficiency. [20] Anger, a common trait of overweight children, is linked to repressed emotions which, again in TCM, creates heat and eventually high cholesterol and high blood pressure. Obesity may be a cause and/or result of stress. As cortisol is released as a response to stress and causes abdominal weight gain, it is another vicious cycle where overweight people feel more stressed and that stress causes a release of hormones that propagate weight gain. The correlation between lifestyle habits, stress and, high cholesterol is apparent. It would be interesting in the next survey to ask specifically what people are eating and emotionally internalizing when stressed.

Sugar and High Cholesterol

The American diet has significantly changed in the past 40 years. According to a recent study published in the Journal of the American Medical Association (JAMA), the average American consumes 21 teaspoons of *added* sugar daily. The average amount of added sugars (such as corn syrup and high fructose corn syrup) constitutes 15.8% of daily calories, compared to 10.6% in the 1970s. [22] Decades ago, high fructose corn syrup did not exist, now it is linked with other sugars to diabetes, obesity, cardiovascular disease, and stroke.

In April 2010, JAMA published a study from information in the National Health and Nutrition Examination Study (NHANES) conducted between 1999 and 2006 to assess the link between added sugars and blood lipid levels of 6,113 adults. [21] Unfortunately, individuals with diabetes and those on high cholesterol medication were excluded from the survey, and it would be very interesting to see where they fell on the spectrum. Participants were placed in five groups, determined by set limits of intake of added sugars of total calories: <5%, 5%- <10%, 10% - <17.5%, 17.5% - <25%, and ≥25%. Blood tests were taken to measure high-density lipoprotein (HDL), triglycerides, and low-density lipoprotein (LDL). A mean of 15.8% of consumed calories came from added sugars. HDL levels decreased as sugar consumption increased, triglycerides increased as sugar consumption increased, and LDL increased in women as sugar levels increased. In the group of participants consuming <5% of added sugar the HDL was 58.7 mg/dL, triglycerides were 105 mg/dL and LD were 116; in the group whose sugar consumption was ≥25% the HDL was 47.7 mg/dL, triglycerides were 114 mg/dL, and LDL was 123 mg/dL. The HDL cholesterol decreased with sugar consumption, while triglycerides and LDL increased. There was a statistically significant correlation between added sugars and blood lipid levels. [21]

Recently, the American Heart Association recommended that women consume no more than 100 calories in added sugar per day (150 calories for men). One can of coke has 140 calories from sugar. A Starbucks blueberry scone has 460 calories, 96 of which come from added sugars, and a small pack of M&Ms has about 130 calories of added sugars. [23] You have reached your daily allotment of sugar if you consume just one of these per day, and that does not factor in the hidden sweeteners that are added to restaurant foods, canned foods, and just about everything else. Most Americans consume far more than their share of sugar per day, especially for those looking for a quick fix on the run.

Sugar is not only a substance that is consumed when people are stressed, [18] but it is added into many, many foods on the market. High fructose corn syrup, an artificial sweetener derived from corn, made its way into breads, ketchup, soups, and many other condiments. Most times, the sweetener is unnecessary. The long-term effect on the body and the question of why it is added raises many more questions. A UC Davis study found that high fructose corn syrup developed new fat cells around their heart, liver, and other digestive organs. [24] Unlike glucose, 100% of fructose is taken up by the liver. This puts added stress on the liver, and returning to TCM, stress on the Liver creates heat which damages blood vessels. As well, up to 30% of the population is incapable of digesting fructose. This disorder, called fructose malabsorption, shows symptoms of irritable bowel syndrome with bloating, diarrhea and/or constipation, flatulence, stomach pain, vomiting, and depression. [25]

Another important factor in the sugar-cholesterol equation is the shape of the sugar molecule. With it's crystalline structure, very jagged edges, and excess hydrogen ions, sugar is responsible for creating free-radicals and tearing the artery walls: injuries that directly correlate to heart disease. Free-radical and artery wall damage begins the chain reaction of inflammation, cholesterol attaching to the artery wall, plaque formation, and atherosclerosis in the body. Free-radicals, especially from cigarette

smoke and sugar, are the most influential in creating damage and tears to the artery walls [4]. A study at the University of Buffalo led by Dr Paresh Dandona found that excess sugar in the bloodstream stimulates the generation of free-radicals. Free radicals in the blood rose significantly 1 hour after individuals drank the sugar drink and levels more than doubled after 2 hours. Those who drank the water-saccharine solution showed no change. The sugar drink was also associated with an increase in a part of an enzyme that promotes free-radical generation, and a slight (4%) decrease in levels of vitamin E, an antioxidant. "The implication is that free-radical damage (leading to) atherosclerotic lesions is definitely mediated by nutrition," Dandona explained. "There is a link between the amount of free radicals and what and how much you eat." [26, 27] “We see free radical cell damage when the body attempts to defend against stress.” Free radical damage results in less energy, and also causes deterioration of the organs and systems of the body. Free radicals are implicated in more than 80% of degenerative disease and hasten the aging process. [30]

Education

One out of five Americans has high cholesterol. Fifty percent (50%) of our population has a level above the desirable limit. [2] There is ample education of watching out for “bad” cholesterol and increasing “good” cholesterol. Physicians strive to lower patient's LDL cholesterol levels through diet change, exercise, and medication. However, the education of the purpose, function, and necessity of LDL and HDL are not discussed. The link between diet, especially sugar, and increased levels of cholesterol is not discussed. Patient's are not taught the “big picture” about why their cholesterol levels are high. This is a serious red flag of American health care. In addition, medical educational websites (like WebMD) are over-burdened with ads from pharmaceutical companies. The message reads: you have something wrong with you, take this pill. Americans are savvy people and very interested in health, if given the proper resources, they will change their life for the better, and likely, without the desire for medication.

A 2010 GALLUP Poll found most Americans (70%) feel confident in the accuracy of their doctor's advice. [28] Only 29% do their own research or feel a need to check themselves. This is especially true for older Americans. This point brings this paper full circle. If physicians commit to take the time to properly educate and get to know their patients and the lifestyle, nutritional, and stressful situations in their life then they have a true ability to help a patient heal themselves. The Hippocratic Oath requires a physician to swear that he/she will uphold certain standards including: [29]

> “avoiding those traps of overtreatment and therapeutic nihilism... understanding may outweigh the surgeon's knife or the chemist's drug... treat a sick human being whose illness may affect the person's family and economic stability...I will prevent disease whenever I can, for prevention is preferable to cure...”

Conclusion

High cholesterol is out of control in America. 100 million people are diagnosed with borderline to high cholesterol; 800,000 people die annually from heart disease. The education is out there. Physicians are available to treat the public. The public is interested in learning. The message; however, is not clear. Americans are confused as to why they have high cholesterol and atherosclerosis while

eating a low-fat, low-cholesterol diet. They are not taught the link between sugar, stress, and the formation of plaques. They are not taught that cholesterol is the body's response to inflammation caused from torn arteries, often caused from stress and sugar consumption. Americans are not taught the dangers of high fructose corn syrup or how much sugar they should consume in one day, and that limit is *very* low. The link between stress and eating is evident. With 75% of Americans feeling more than their limit of stress on a daily basis, there is no wonder why heart disease is rampant. Something must change. We must slow down. Laugh. Eat proper meals that come from the earth. Speak with a physician that is a healer dedicated to our well-being without the use of medication. The message needs to change: Cholesterol is our friend, sugar is not.

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