The Heart: Part 2

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This month we will talk about the various ways to look at the heart, and the way coronary artery disease develops, it's "natural history," and the role of inflammation as a core problem. Next, to introduce what we can do to delay or help cardiovascular disease, diet and exercise are our next topics. Many people make a big mistake, thinking diet and exercise do not compare to the most potent prescription medications in effectiveness, and some actually prefer to take nine pills a day, rather than follow a sensible, prudent, healthy lifestyle. Worse, they may believe surgery will keep them from death's door when they continue unhealthy lifestyles, when the ultimate truth is that bad habits will handily reverse any beneficial effects from surgery. Imagine, many pills and several hundred dollars monthly, just to go to fast food restaurants and be couch potatoes, and they still lose in the end.

Ways to Look at the Heart

As a Pump. The heart is no longer viewed simply as a "pump," as it was many years ago. On average, it pumps 1500 gallons of blood per day, generating enough power to drive a car 20 miles each day. Still, the amount of blood the heart pushes out or ejects, compared to the full amount of blood it contains, is an important overall index of heart function. Most people know the heart contains four chambers, two receiving blood from the lung and body, the right and left atria (atrium, singular) respectively, and two that pump blood out to the lungs and body, the right and left ventricles, respectively. The job of the atria is to see to it that the ventricles are filled. [See "How the Heart Works," animated, at http://www.nhlbi.nih.gov/health/dci/Diseases/hhw/hhw_all.html]. The left ventricle normally pumps from 55%-75% of the blood it contains out to the body with each beat. The corresponding fraction, 0.55-0.75, is called the "ejection fraction," and is measured both directly during cardiac catheterization and indirectly from an echocardiogram. An EF of 0.40-0.50 usually means damage, but a normal EF can occur even when the heart is damaged.

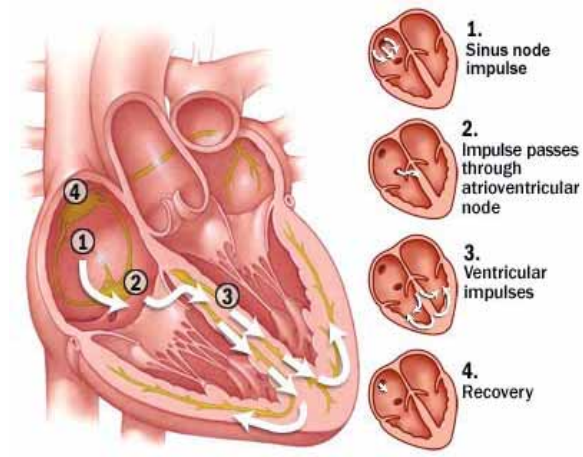
Normally all parts of the muscular ventricles contract in a coordinated way, to maximize the amount of blood ejected. In disease, some portions of the heart muscle may not be able to contract as much as other, normal areas. When one area of muscle cannot contribute significantly to the ejection of blood, the "**synergy**" of contraction is impaired. This may be temporary, during an episode of angina, when blood flow to an area of muscle is low, or it may be permanent, as a result of a heart attack, with the death of heart muscle followed by scarring. The total amount of blood flowing through the coronary arteries supplying the heart muscle with oxygen and nutrients is evaluated during cardiac catheterization, at which time the coronary arteries are visualized, and any blockage(s) are identified. Over 80% blockage at a particular point is serious and usually associated with symptoms. The amount of blood flowing through the muscular walls of the heart may be evaluated during various "perfusion scans," during which non-performing areas of the heart wall are visualized.

As an Electrical System. When resting, the adult human heart beats at about 70 BPM* (males) and 75 BPM (females), but this rate varies among people. A normal heart rate is from 80-100, but a resting heart rate over 90 may be a sign of trouble. The heart beats an average of 2½ billion times during a lifetime, but the idea that each person has a fixed number of heartbeats to his/her life is untrue. Most cells in the heart have the intrinsic ability to beat and generate electricity, but certain cells, because they generate and conduct electricity faster than other cells, are part of a specialized electrical or conducting system of the heart. The first cells to create an electrical impulse that will eventually cause a single heart beat are in the "sinus node," located near the back left atrium. The impulse travels down special fibers through the center of the conducting system, the "A-V node," then into the ventricles, where is spreads throughout the ventricular muscle to initiate a musclular contraction. The conducting fibers and muscle recover and recharge, getting set for another heartbeat.

When the heart is going too slow, too fast, or its rhythm is irregular – also called an arrhythmia – the heart may not pump enough blood to sustain blood pressure or supply the body with enough oxygen and nutrients.

Other Ways to Look at the Heart. The **biochemical composition** of the heart may be altered, if, for instance, potassi-

Initiation of a Heartbeat Through the Specialized Conduction System of the Heart



In a normal heartbeat, a tiny group of cells called the sinus node begins an electrical signal (1). The signal then travels through the atria and passes through another group of cells called the atrioventricular (A-V) node (2). From the A-V node, the signal travels through the ventricles (3), causing them to contract and blood is ejected. Then all cells recover (4), and the sequence is repeated during the next beat. **BPM=beats per minute*

um or magnesium is depleted in the muscle. Another example is a relative depletion of a chemical needed for energy production within the heart cells, such as coenzyme Q10. The heart also secretes hormones, and participates in various cardiovascular reflexes.

After any intervention to the heart, whether it is dietary, medications, or supplements, one must ask, what will be the effect on muscular contraction, on the conducting system, on blood flow to the heart, on perfusion of the heart wall with blood, and on the biochemistry of the heart? For instance, fish oil may reduce the area of heart muscle that dies when coronary blood flow is lowered and promotes coronary artery dilation. It may also lower the incidence of certain harmful arrhythmias, lower the level of blood fats (triglycerides), and decrease the number of sudden cardiac deaths.
Biochemically, the activity of the damaging superoxide free radical is lowered. On the other hand, cocaine may raise heart attack risk 24-fold during the first hour after ingestion, bring about spasm of arteries and strokes, increase the levels of clotting factors, raise an index of inflammation, promote potentially fatal arrhythmias and sudden death, and stimulate an enzyme in the heart which stimulates abnormal heart muscle overgrowth, or hypertrophy, among others. In these instances, the effects seem all good for fish oil, and all bad for cocaine. Sometimes, however, the effect on one aspect, such as muscle, may be favorable, and on another, unfavorable, such as causing arrhythmias.

How Does Heart Disease Develop?

Atherosclerosis of the coronary arteries is a chronic inflammatory condition in which the inner walls of arteries stiffen and become clogged. As deposits build up, they protrude into the artery, decreasing its diameter, so that less and less blood can flow through it. Actually, the process is more complicated. First, the inner wall, called the **endothelium**, is damaged in some way, possibly from high blood pressure, cigarette smoke toxins, high levels of cholesterol and fat (lipids) in the blood, changes of diabetes, even infections. Inflammation occurs as a natural way for the body to repair itself. Various inflammatory chemicals, called cytokines, are released that increase clotting, cause blood vessel spasm, stimulate cell growth, attract other cells, and amplify the inflammatory process. Platelets, components of blood that initiate clotting, are activated, and accumulate, together with white blood cells (monocytes, lymphocytes). The smooth muscle in the arterial wall thickens.

As part of the process, damaging, high energy particles are released called "free radicals," which change "bad" cholesterol – LDL – in the blood to its oxidized form. The clotting components called fibrinogen and platelets, together with oxidized LDL, all become sticky, and adhere to the endothelial lining. These particles then migrate into the inner wall of the artery from the blood, and begin to trap other components, such as calcium. Large white blood cells form and ingest the particles of oxidized LDL, attempting to destroy them. But they too become stuffed and trapped. The entire mass of particles, dead white blood cells, cholesterol, smooth muscle, and later, calcium, form what is called a "plaque." When seen through the microscope, a plaque has a "cap," derived from smooth muscle cells, and a core of oxidized LDL, white blood cells, and cell debris, meaning left-over dead parts and trash. During repeated cycles of inflammation, more and more components are added to the plaque. As it grows, three things may happen: (a) the inside of the artery narrows, so less room is available for blood to flow past the plaque, or (b) the cap may become thin, and enzymes may liquefy the core, and the plaque may rupture, allowing a blood clot to form at that site. If blood flow to an area of heart muscle is blocked, the heart muscle may die quickly, producing what is called a myocardial infarction, or heart attack.
Or, (c), part of the clot may break apart, travel in the blood, and cause blockages elsewhere. This process is known as **embolization**, and the migrating clots are called **emboli**.
Plaque rupture accounts for about 75% of all acute coronary events. For an illustration of the process, visit http://www.nhlbi.nih.gov/health/dci/Diseases/HeartAttack/HeartAttack_WhatIs.html. Oxidation, inflammation, and clot (thrombus) formation are the key processes. The cholesterol component, oxidized LDL, is a participant in the buildup, but is not the root "cause" of the problem. Still, high levels of LDL cholesterol alone can inflame the endothelium.
[Oxidation can be regarded as the biological equivalent of rusting. Antioxidants retard this process].

Risk Factors

What are the factors that raise the risk of atherosclerosis? They are usually divided into those that we cannot do much about, and those that we can.

Nonmodifiable Risk Factors (Cannot be changed)

1. **Age**
2. **Gender**
3. **Family history** – Inherited tendencies
4. Personal history of cardiovascular disease
5. Coexisting other diseases, such as kidney disease, that are inherited in large part

Modifiable Risk Factors (Can be changed)

1. **Smoking** cigarettes, cigars, or chewing tobacco
2. **High blood pressure**
3. **Overweight and obesity**, especially visceral or abdominal obesity ("apple" rather than "pear" shape)
4. High levels of **cholesterol** in the blood: low density lipoprotein [LDL or "bad cholesterol, or other cholesterol particles: very low density lipoprotein (VLDL), lipoprotein "little a" (Lp(a)), and others], or very small, dense, LDL particles
5. Low levels of protective high density lipoprotein (HDL, or "good" cholesterol)
6. High levels of triglycerides (common fat) in the blood

7. **Diabetes** (high glucose or high insulin levels, insulin resistance)
8. Metabolic Syndrome (high glucose or insulin levels, insulin resistance)
9. Physical **inactivity**
10. Inflammatory states, including high levels of C-reactive protein (CRP)
11. Inflammatory diseases elsewhere in the body: rheumatoid arthritis, gout, others
12. High levels of homocysteine in the blood (some forms are inherited but may still be modified)
13. Chronic dehydration
14. High levels of fibrinogen in the blood
15. Low levels of free testosterone in the blood
16. Chronic kidney disease
17. Stress, hostility, maladaptive chronic anger, "hot reactors"
18. Depression

Other Factors or "Markers" That are Associated with Heart Disease

1. High levels of an enzyme called myeloperoxidase in the blood, a marker for inflammation
2. Persistent elevations of white blood cell counts
3. Low blood levels of vitamin K
4. High blood levels of phosphorus
5. High values of a marker in the blood called B-type natriuretic peptide (BNP)
6. Blood renin content (a hormone released by the kidney that raises blood pressure)
7. Ratio of the level of a protein, albumin, to a chemical, creatinine, in the urine
8. Certain drug abuse
9. Male pattern baldness
10. Low levels of anti-inflammatory omega-3 fats in the blood and tissues
11. Low or high thyroid function
12. Low potassium intake
13. Resting heart rate over 90
14. Small stature
15. Sleeping disorder/obstructive sleep apnea
16. Very high or very low protein intake
17. Small arterioles (small artery divisions) and/or large venules in the retina (back of the eye tissue)

It has been said that 90% of the time, heart risk may be predicted using only the classical, more important risk factors (**bold**), and that the "novel" risk factors need only be considered 10% of the time. Certain ones, for instance, fibrinogen, is capable of increasing the incidence of heart attacks two- to four-fold. C-reactive protein is not only an important marker for inflammation, but also a cause of further inflammation. Up until now, a composite risk factor was calculated according to data from the Framingham Study, predicting chances of a heart attack over the next 10 years. This Risk Assessor Tool figured in age, gender, total and HDL cholesterol, smoking history and systolic blood pressure to calculate risk. In women, up to 20% of all coronary events occur without these risk factors. Earlier this year, a more accurate Reynolds Risk Score was validated for nondiabetic women, which includes a history of heart attack before age 60 and the CRP value.

A recent study tracked over 15,000 people who adopted just 4 improved habits after age 45. Just 4 years after they did, they were 35% less likely to have heart disease, and 40% less likely to have died over 4 years than those who did not adopt the good habits. They were (i) eating 5 servings of fruits and vegetables daily, (ii) exercising at least 2½ hours per week, (iii) controlling weight, and (iv) not smoking.

Next month, we will talk more about the role of diet, physical activity. Then we will begin reviewing a list of what you yourself can do for high blood pressure and coronary artery disease. Selected references are available upon request from rkones@houston.rr.com or by telephone at 713-790-9100.