DIGITAL PULSEWAVE & HRV TRAINING

SA3000P

Digital Pulsewave Analyzer

Cardio Wave Analyzer

Dr. Harry Elwardt, Ph.D.
Instructor

Introduction

Congratulations on your decision to join our team as a Certified Pulsewave and HRV Technician. Make sure you study each part of this manual. There will be a test on each part, as well as an annual exam in order to renew your certificate each year. I also strongly urge you to read my book, "Let's STOP the #1 Killer of Americans Today!" Although you will not be tested on this information, it is a tremendous tool to further your knowledge on the cause and prevention of cardiovascular disease.

When you are fully trained, you will have the ability to influence countless lives in a positive and rewarding way. Remember never to over step your bounds as a technician by playing doctor. The rest of the slides in this introduction are critical to your understanding and implementation.

Welcome aboard!

Harry A Elwardt, N.D., Ph.D.

Training Outline

- Study Intro Section
- Study Part 1 (Understanding Cardiovascular & Arterial Health)
- Study Part 2 (Understanding Pulsewave Analysis)
- Study Part 3 (Understanding Heart Rate Variability Analysis)
- Complete the quiz at end of Parts 1-3 and email to:
  zaleatley@gmail.com or fax to 512-396-0629
- If you fail any test you will be informed which questions you got wrong, just re-submit answers to those specific questions
- If you pass all 3 quizzes, you will receive a congratulatory email. A certificate signed by Drs. Zale Atley and Moneca Ryane will be mailed out to you within 48 business hours.

Beware of Your Words

WHAT AN UNLICENSED PRACTITIONER
MAY OR MAY NOT SAY AND DO

Regardless of your status and rights, the words you use and your actions can help immensely to keep you out of trouble.

WORDS TO AVOID

- In the healthcare field, certain words have been given legal meaning in the state statutes. Even if the statues are not constitutional, or your work outside of them, one is advised to avoid using words that are generally reserved for licensed practitioners. These words include: ***cure, diagnose, prescribe, treat and possibly even the word disease.***

- Instead of the word ***cure,*** use the words alleviate, improve, correct, balance or normalize a condition.

- Instead of the word ***diagnose,*** one may assess, measure, determine or evaluate a condition.

Beware of Your Words

- Instead of the word ***prescribe*****,** one may recommend, suggest, advise or offer options to alleviate a condition.

- Instead of the word ***treat,*** one may handle, work with, relieve, balance, normalize, ameliorate, correct or remedy a condition.

- Instead of the word ***disease,*** one may prefer the words 'condition', 'problem' or 'imbalance'. Instead of naming specific diseases, it is better to use simple, descriptive terms. For example, you might say to a client, "I see you have swollen joints", rather "I see you have arthritis". Arthritis may be considered a medical diagnosis.

Making Claims

A good rule is not to promise anything except that you will do your best. Certainly never promise a cure! It is best to explain to clients that restoring health is an individual matter and that there are many approaches. You offer certain approaches, and will do your best. There are no guarantees. You may say that others have been helped, or that 80% have been helped, or some such phrase.

Do Not Diagnose

In healthcare and other fields, words have powerful effects. It is best not to use diagnostic terms loosely. Diagnosis is the realm of the medical doctor. A diagnosis requires a specific procedure or test in many cases. If you suspect a serious condition is present, it is always best to refer the person to a practitioner qualified to make the diagnosis.

Do Not Misrepresent Yourself or Your Work

Misrepresenting yourself or your work is a fast way to create legal problems. Areas where this can arise include your speech, stationery, business cards, written articles, or the speech of your secretary/receptionist or anyone else who represents you. And never wear clothes that would impersonate a doctor or nurse, like scrubs or a lab coat. This is a sure way to draw attention to yourself and bring down the full wrath of the authorities.

An alternative and safe way to describe yourself is to list areas in which you work, such as nutrition, lifestyle counseling, health, personality, education, etc. Do not use words such as law, medicine, chiropractic or psychology, however unless you are licensed. These are 'protected' words.

Do Not Disparage Other Practitioners

This is a professional gesture, but is also very wise from a legal standpoint. It is often best not to state that another practitioner is wrong – even if he or she appears to be. You never know when you will insult someone and cause them to take action against you. Instead, why not say you see things differently, you have a different view, you are of a different opinion, or you offer an alternative viewpoint.

Disparaging others also confuses clients, and can interfere with the trust a client has for you, as well as for others. For example, when a healer categorically tells me that another healer's work is not good, I tend to lose faith in the person who tells me this.

Stopping Medication

The issue of disparaging doctors is particularly important when a client is taking prescribed medication. If you tell someone for example, a particular medication is dangerous and to stop taking it, you could be held liable if there were negative consequences.

It is far better to say that with alternative methods a time may come when the medication will not be necessary, but that you do not suggest the client stop his medication. That is a matter to be discussed with one's medical doctor. Some medication can be reduced on one's own, if handled cautiously and with full knowledge of all the possible consequences

Treat People Kindly & Fairly

There is no substitute for courtesy and consideration. Service is what this business is all about. Good service, courtesy and consideration are the most important ways to avoid problems, improve business and improve the image of your profession. Never forget that you represent others in your field to a public that knows little of what you do or who you are.

Unlicensed practitioners are often held to higher standards than those who are licensed. One can resent this fact, but holding to high standards of ethics and conduct benefits you as much as it benefits your clients.

Part 1

Understanding Cardiovascular & Arterial Health

Goals

- Understand the role of the endothelium in health and disease
- Conceptualize the mechanisms behind endothelial damage
- Learn how endothelium damage can be detected
- Learn how endothelial function can be improved

Cardiovascular Disease A Global Epidemic

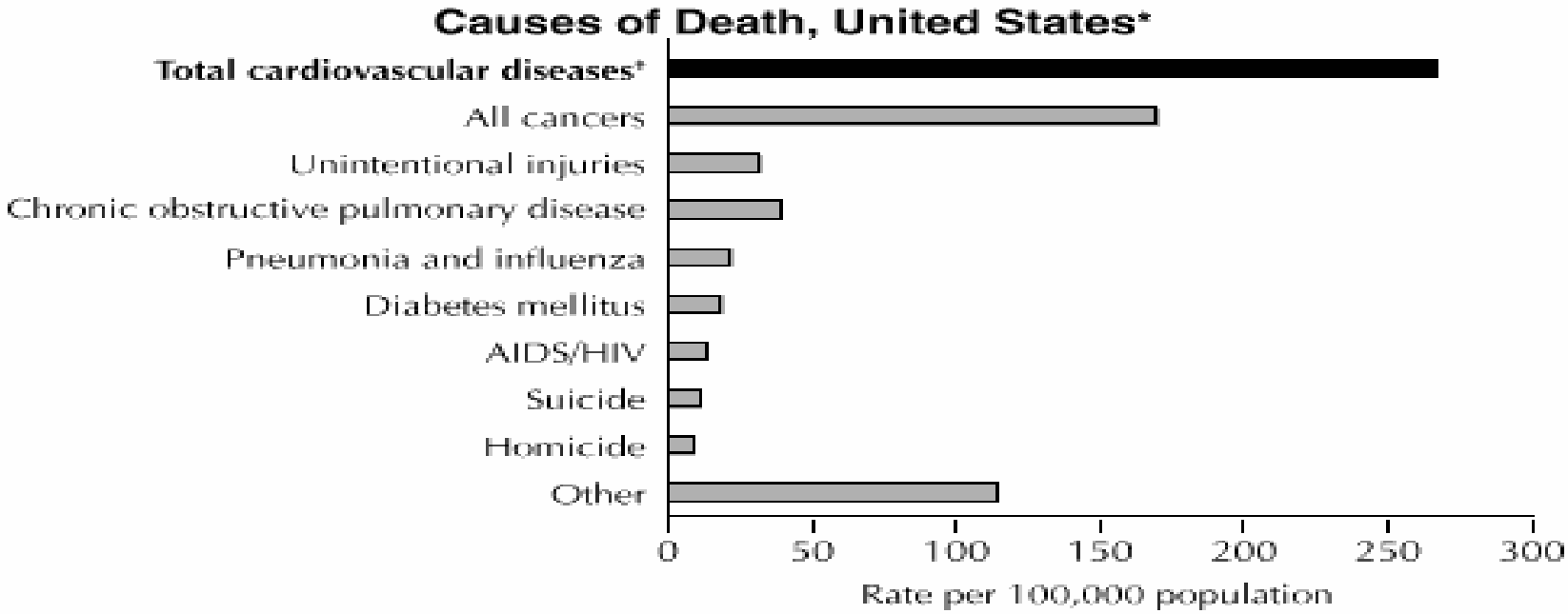
- By the year 2020, CVD deaths is expected to surpass infectious diseases as the leading cause of mortality and disability
- CVD is the leading cause of death in both males and females in Western societies
- 1 million deaths due to vascular disease in 1994 (twice as many as from cancer and 10 times as many as from accidents)

Cardiovascular Disease Global Epidemic

- Cardiovascular disease is the major cause of death in the United States; it claims more lives than all other diseases combined
- Worldwide it is estimated that more than 12 million people die every year from cardiovascular disease
- Represents more than 30% of all deaths worldwide

Causes of Death in 1995

MMI



* All data are age-adjusted, 1970 total U.S. population.

† Total cardiovascular disease death rate includes the rate of death due to ischemic heart disease (135.2 per 100,000) and the rate of death due to stroke (42.5 per 100,000).

Source: National Center for Health Statistics and National Center for Chronic Disease Prevention and Health Promotion, Centers for Disease Control and Prevention, 1995.

Cardiovascular Disease

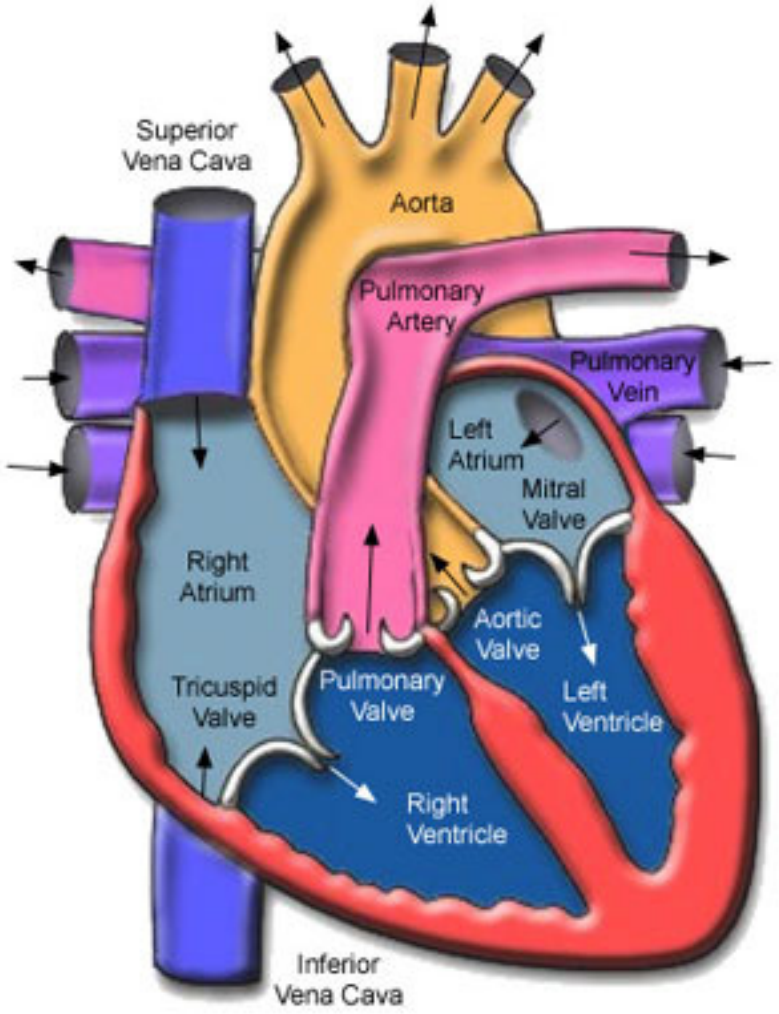
- Refers to diseases of the heart (cardio) and diseases of the blood vessels (vascular i.e. arteries, capillaries, veins)
- Angina, heart attacks, heart failure (CHF), stroke, peripheral vascular disease, chronic kidney disease, retinopathy, arteriosclerosis, atherosclerosis, sexual dysfunction

Risk Factors (CVD)

- Hypertension
- High Cholesterol
- Diabetes
- Cigarette Smoking
- Obesity
- Physical Inactivity
- Dyslipidemia
- Poor Kidney Function
- Family History
- Gender--Men >45yrs or Women>65yrs
- Race—Hispanics & Black Americans 5Xs more likely

The Heart

From the moment it begins beating until the moment it stops, the human heart works tirelessly. In an average lifetime, the heart beats more than two and a half billion times, without ever pausing to rest. Like a pumping machine, the heart provides the power needed for life.



The Heart's Function

- The heart is one of the hardest working organs in the body; it contracts and expands about 100,000 times every day.
- It supplies a blood vessel network approximately 59,650 miles long and pumps in excess of 10,500 quarts of blood around the body every single day.
- The heart pumps returning blood through the lung capillaries where waste gas, primarily carbon dioxide, is expelled and fresh oxygen is taken up by the blood.

The Heart's Function

- Between beats, the aging ventricle fills with blood more slowly because it is relaxing more slowly than it did when it was young.
- From the lungs the now oxygenated, bright red blood is pumped through the aorta into the smaller arteries, the capillaries; where the actual nutrient and oxygen exchange with individual body cells takes place, and then back to the heart through the veins.
- Immediately after exiting from the heart the aorta branches off into the right and left coronary arteries which supply the heart itself with fresh blood and the nutrients it needs. The coronary arteries are attached directly to the wall of the heart and are squeezed and expanded 100,000 times a day. This constant stress makes them especially vulnerable to damage and disease.

The Heart & Aging

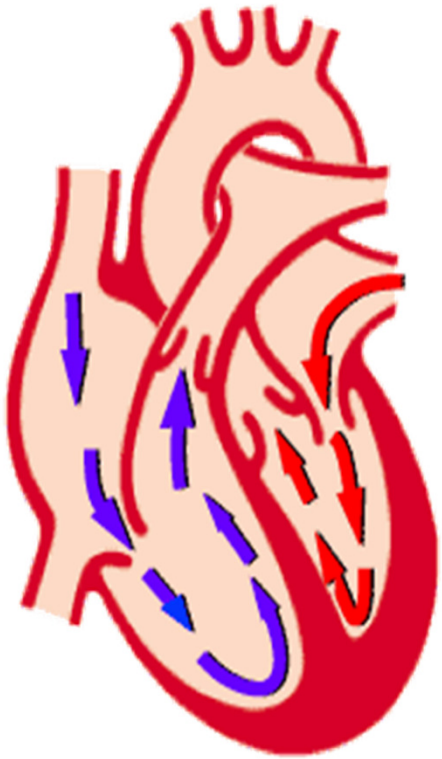
- With advancing age, the cardiovascular system undergoes subtle but progressive changes that result in altered function.
- The endocardium becomes thicker and opaque, left ventricular (LV) wall thickness increases.
- Although myocyte size increases, the number of myocytes decreases, as does the number of cells in the conduction system.
- The decrease in the filling rate of LV in early diastole is accompanied by a greater rate of filling in late diastole augmented by atrial contraction.
- Maximum achievable heart rate and ejection fraction (with exercise) decreases.

Heart Dynamics

- Early diastolic filling slows as people age
- Between beats, the aging ventricle fills with blood more slowly because it is relaxing more slowly than it did when it was young.
- The heart compensates for the slower early filling rate by filling more quickly in the late diastolic period.
- As the mitral valve slowly closes, incoming blood from the lungs pools in the left atrium, which is now larger and holds more blood than when young.
- The left atrium, stretched with a greater volume of blood in older hearts, contracts harder, pushing open the valves and propelling the blood into the ventricle.

Heart Dynamics

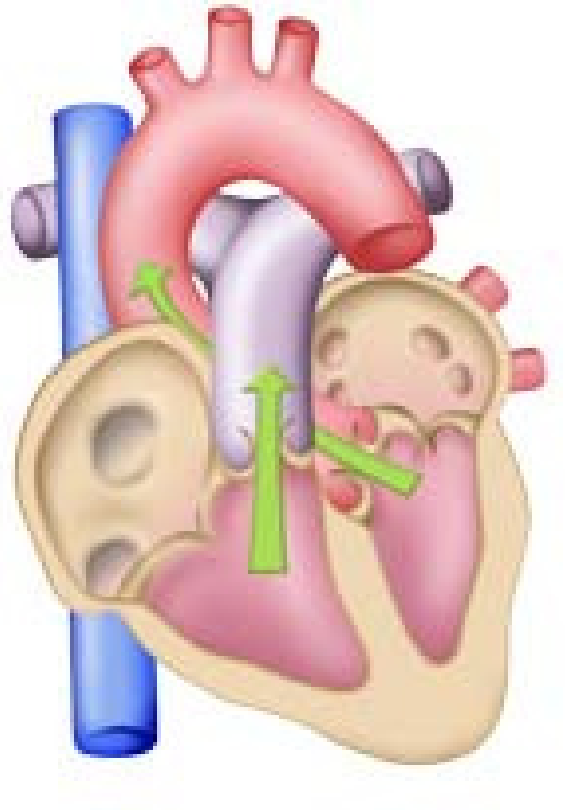
- In younger people, about twice as much blood flows into the ventricle during the early filling period than during late filling.
- As we age this ratio changes so blood flow during early and late filling is about equal.



Heart Dynamics

Next step – Contraction or Systole

- Picture the left ventricle at the end of diastole filled with a volume of blood that is equal to or slightly greater than the volume in younger hearts (end diastolic volume).
- When the contraction occurs, it forces out a certain amount of blood – the stroke volume.
- However, not all the blood is pumped out at once.
- A portion remains in the ventricle – the end systolic volume.

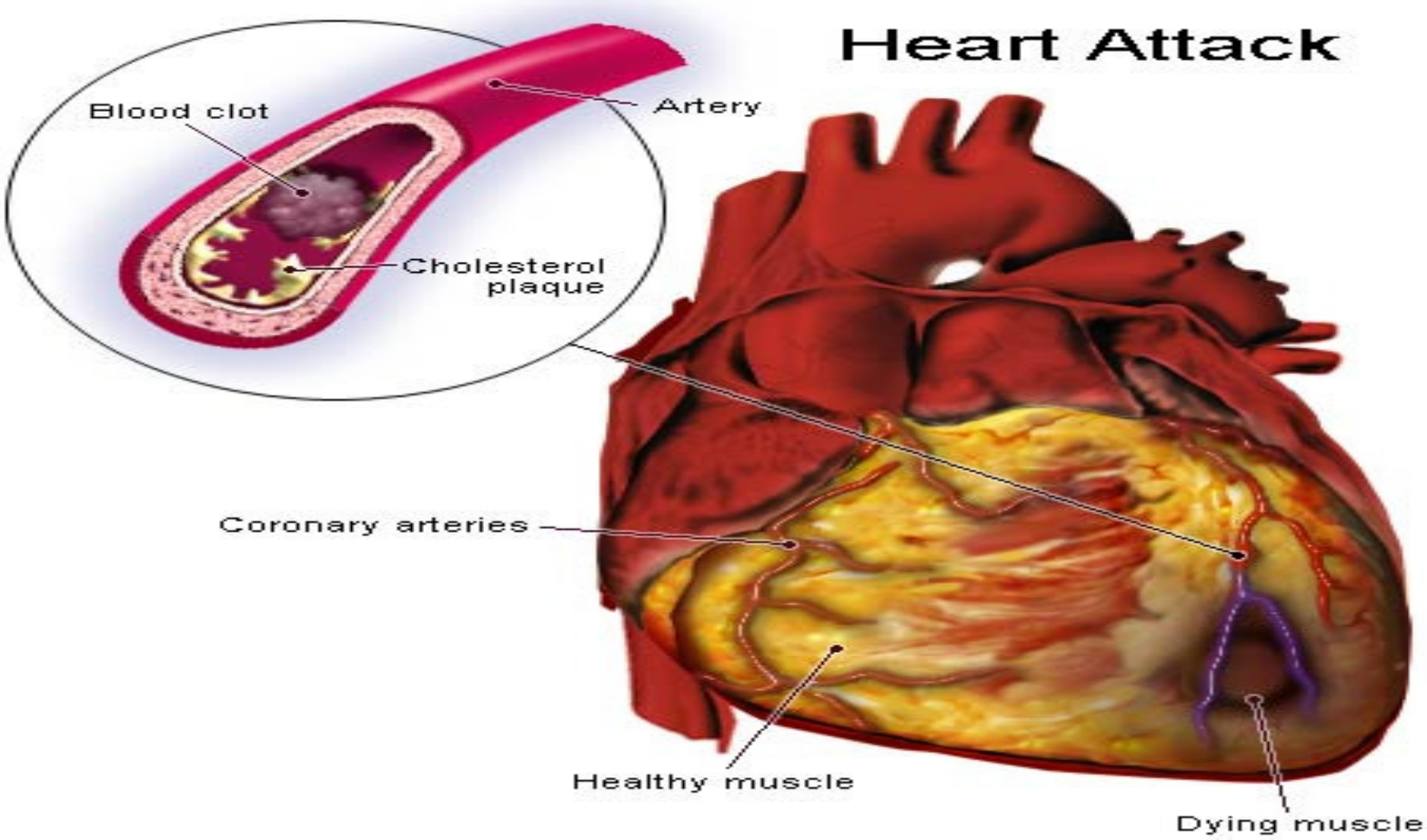


Heart Dynamics

Next step – Contraction or Systole

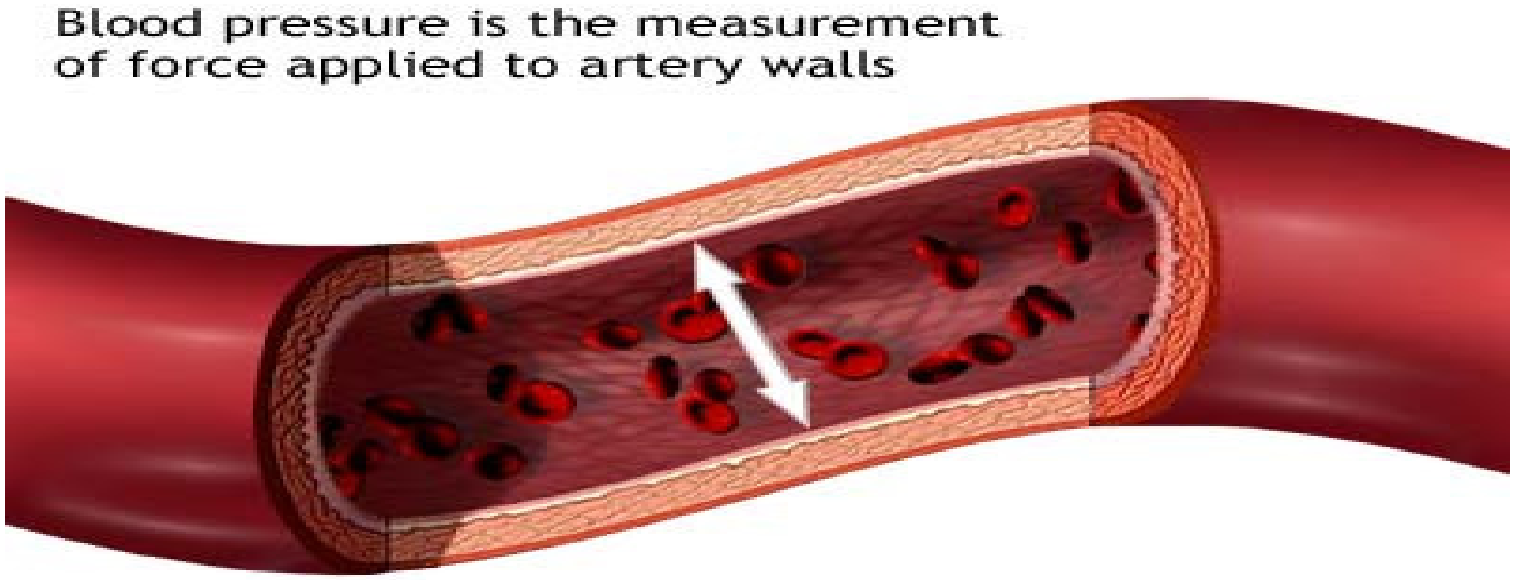
- The proportion of blood that is pumped out during each beat compared to the amount that remains in the heart at the beginning of the next beat is called the ejection fraction.
- Doctors frequently use the ejection fraction to estimate how well the heart is pumping.
- These measurements are important because links between end diastolic volume, stroke volume, end systolic volume, and ejection fraction make up a complex set of dynamics that researchers use to understand the differences aging makes to the hearts pumping ability.

Heart Attack



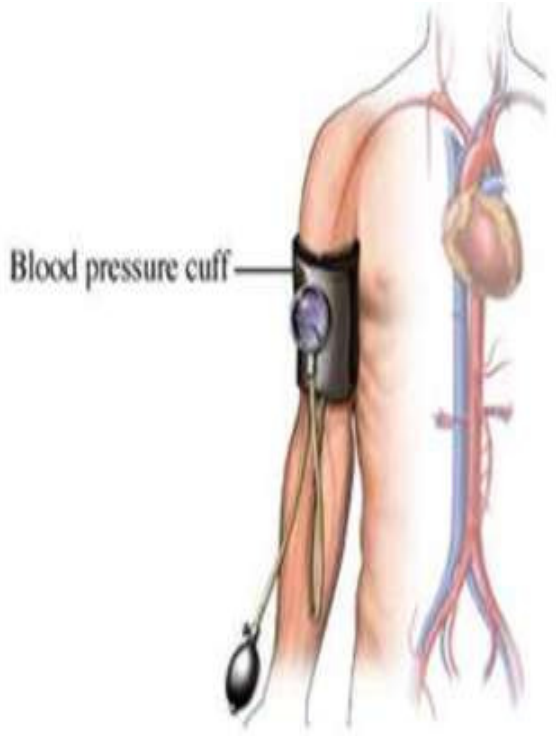
Blood Pressure - Defined

Blood Pressure is the force of blood against the walls of the arteries. Blood pressure rises and falls during the day. When blood pressure stays elevated over time, it is called *high blood pressure.*



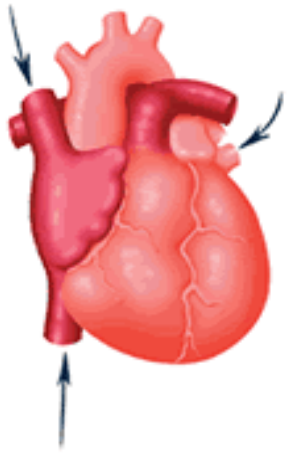
High Blood Pressure - Causes

- The causes of high blood pressure vary. Causes may include narrowing of the arteries, a greater than normal volume of blood, or the heart beating faster or more forcefully than it should.
- Any of these conditions will cause increased pressure against the artery walls. High blood pressure might also be caused by another medical problem. Most of the time, the cause is not known. Although high blood pressure usually cannot be cured, in most cases it can be prevented and controlled.

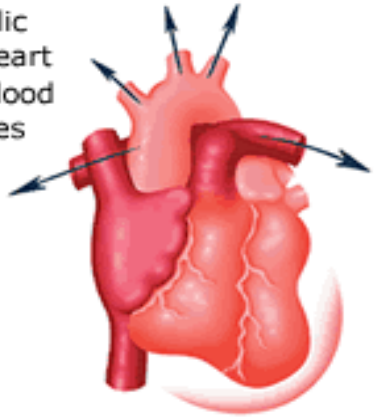


Blood Pressure Levels – Diastolic/Systolic

DIASTOLIC.
In the diastolic phase the heart relaxes, blood pressure falls and blood fills the heart.



SYSTOLIC
In the systolic phase the heart contracts, blood pressure rises and blood moves out along the vessels.



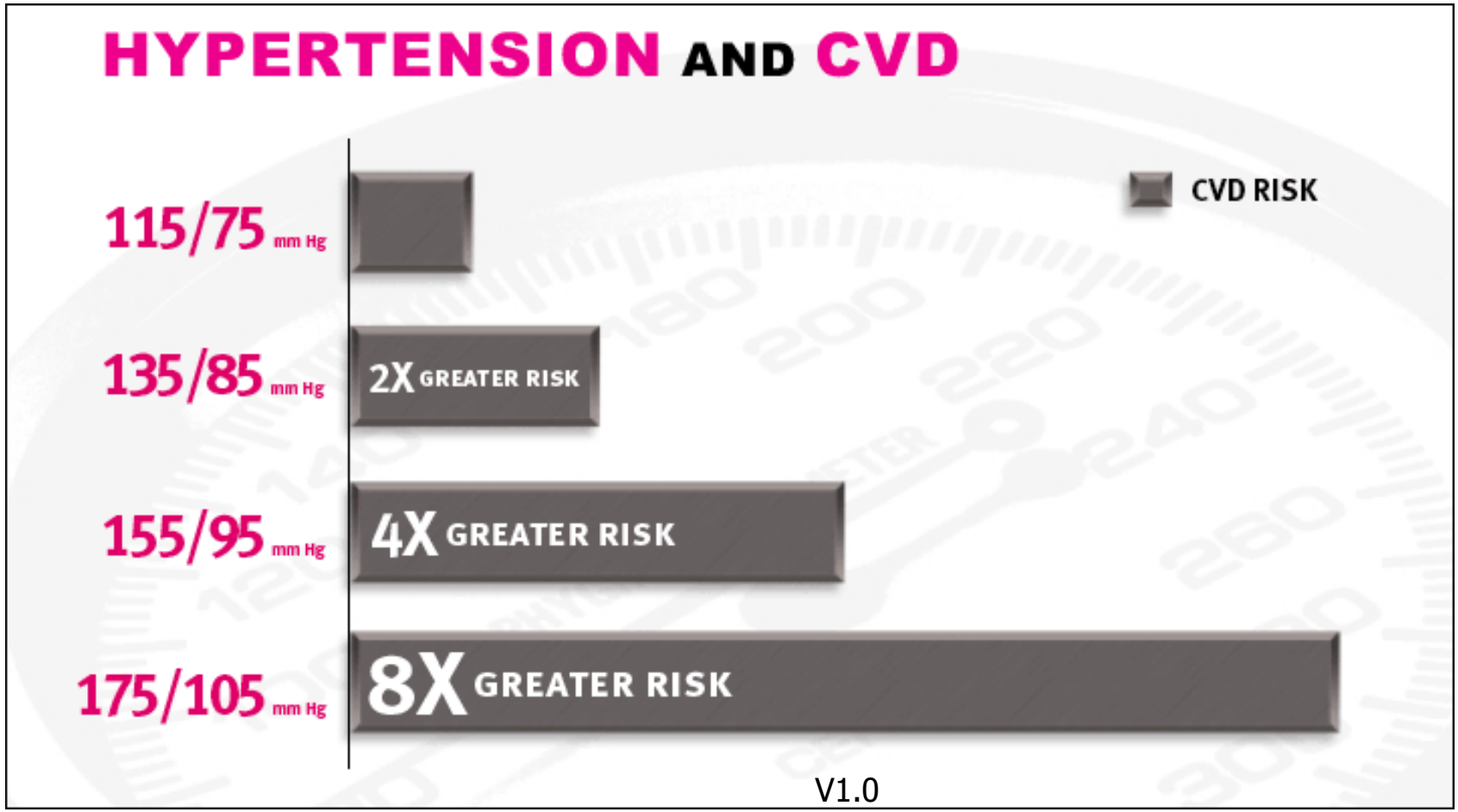
The <u>diastolic pressure is the bottom number</u> <u>in a blood pressure reading</u>. The diastolic number remains, especially for younger people, an important hypertension number. The higher the diastolic pressure, the greater risk for heart attacks, strokes and kidney failure.

The <u>systolic pressure is the top number in a blood pressure reading</u>. Both numbers are important, but for people 50 or older, systolic pressure gives the most accurate information for diagnosing high blood pressure

Blood Pressure Levels

Normal BP	= Systolic <120mmHg
	= Diastolic <80mmHg
Pre-hypertension	= Systolic BP 120-139 or
	= Diastolic 80-89
Stage I HTN	= Systolic 140-159 or
	= Diastolic 90-99
Stage II HTN	= Systolic $\geq$160 or
	= Diastolic $\geq$ 100

Blood Pressure Levels



High Blood Pressure Defined

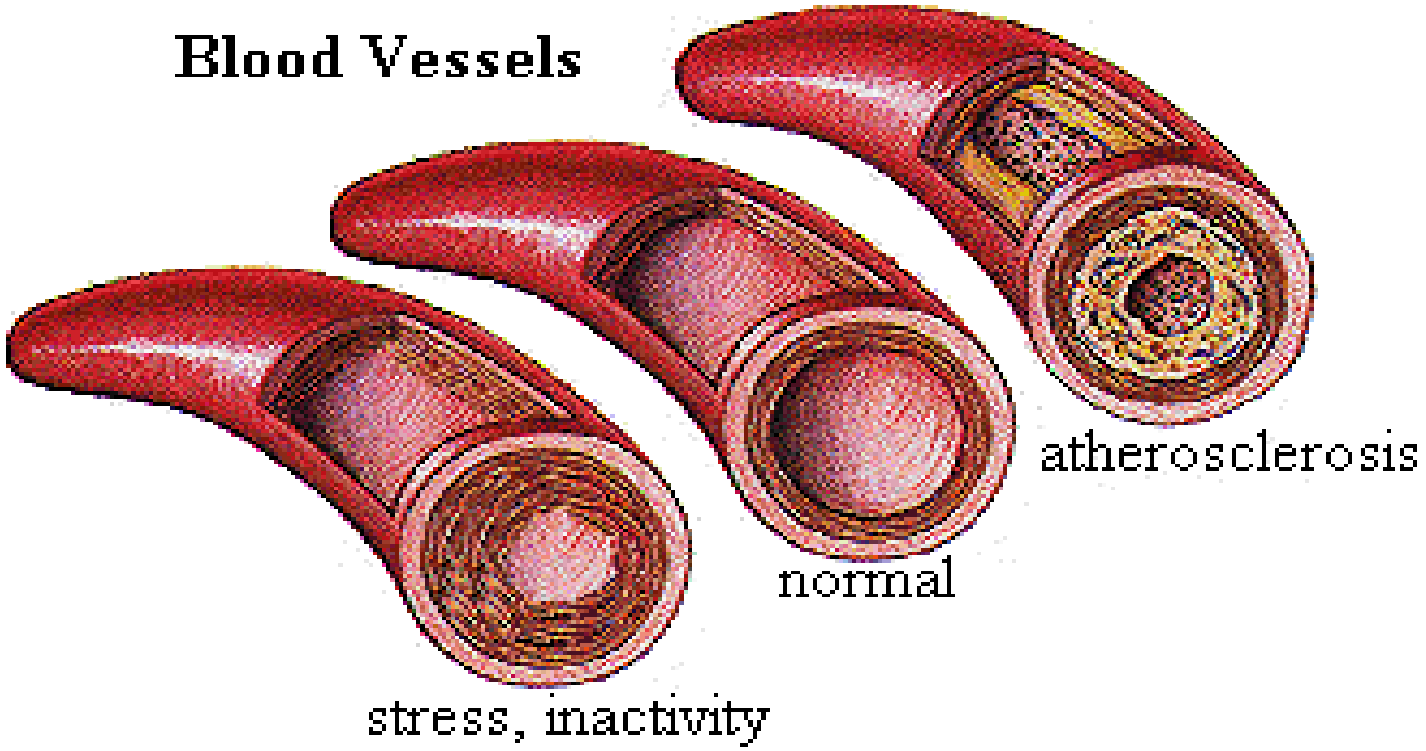
Hypertension: is the medical word for high blood pressure.

High blood pressure is dangerous because it makes the heart work too hard and contributes to atherosclerosis (hardening of the arteries).

It increases the risk of heart disease and stroke, which are the 1st & 3rd leading causes of death in the United States.

Those who do not have high blood pressure at age 55 face a 90% chance of developing it at some points in their lives – so **high blood pressure is a condition that most people have at some point in their lives** – *National Heart Lung and Blood Institute.*

Effects of High Blood Pressure



Blood Pressure Medications

Here is a list of the main types of pharmaceutical drugs prescribed for high blood pressure:

- **Diuretics**
- **Beta-Blockers**
- **ACE inhibitors**
- **Angiotensin antagonists**
- **Calcium channel blockers (CCB's)**
- **Alpha-blockers**
- **Alpha-beta-blockers**
- **Nervous system inhibitors**
- **Vasodilators**

Please note that if these medications are working properly the DPA can measure this efficacy. The information may indicate proper healthy values if the medication is working for that individual.

Hypertension Statistics

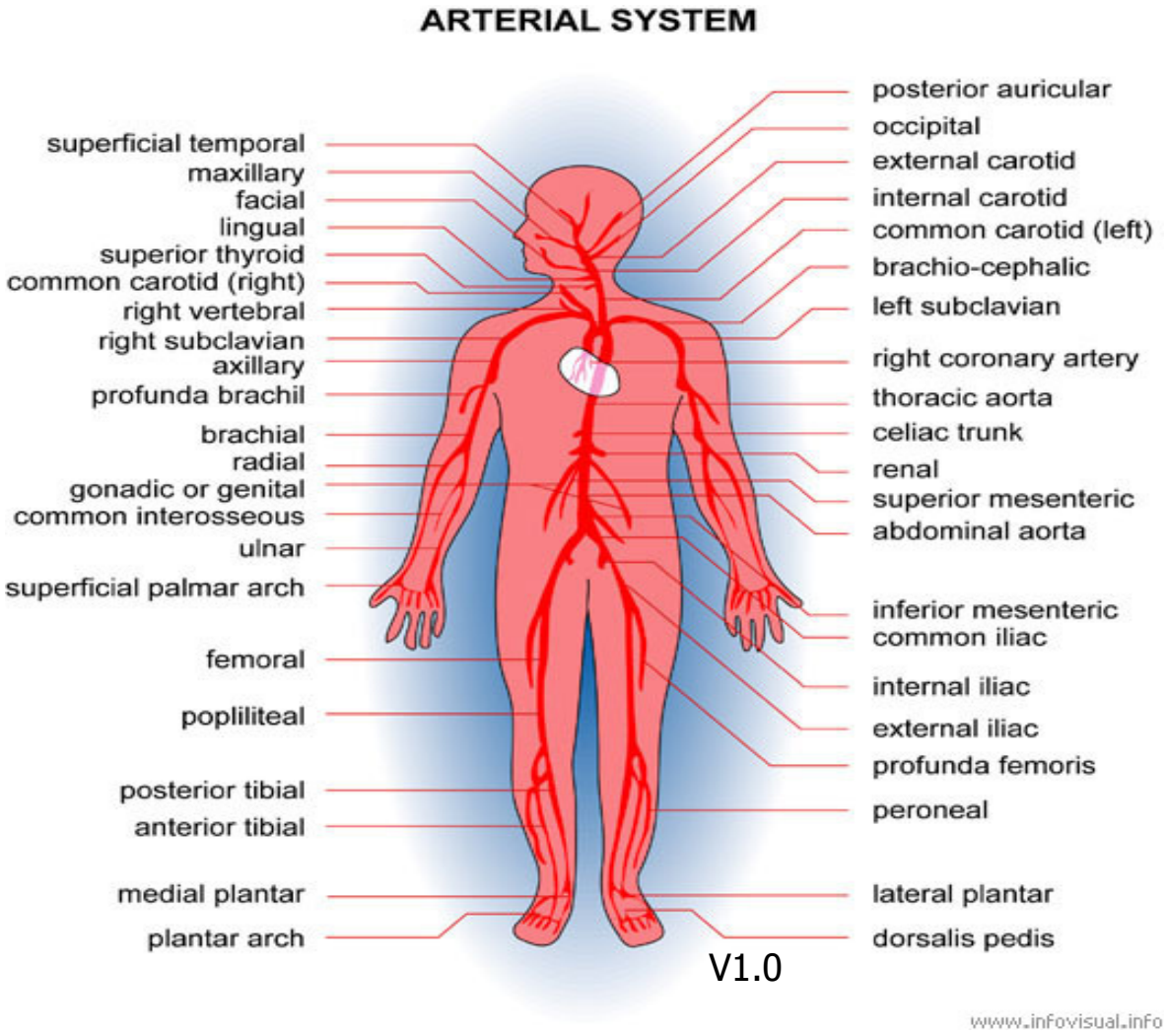
- 50 million people in the USA have HTN
- 1.5 million people have heart attacks every year in the USA
- HTN is diagnosed in more than 13% of Caucasians
- HTN is diagnosed in more than 40% of African Americans. It begins at an earlier age and is usually more severe than in Caucasians.

Heart disease is the biggest killer of women no matter what their race or ethnic group. However, African American women are more vulnerable; they are about one third more likely to die from the disease than Caucasian women. Between the ages of 35 and 74, the risk doubles.

The Arterial System

- Stretched end-to-end, the arteries, veins and other vessels of the human circulatory system would measure up to 100,000 miles.
- In an average lifetime, the heart pumps approximately one million barrels of blood through the circulatory system.
- But – as we age, the heart and arteries become more susceptible to diseases including high blood pressure and atherosclerosis.
- By age 80 men are nine times more likely to die of chronic heart failure than at age 50. Among women, this risk increases 11-fold over the same time period.

Arterial System



The Arterial System

- Poor lifestyle choices – smoking, lack of exercise, high-fat diet, cholesterol and sodium contribute to the development of cardiovascular diseases.
- However, with advancing age the arteries undergo changes – including arterial stiffening and thickening, which are major risk factors for cardiovascular disease.
- Age related changes also make it easier for fatty deposits to build up on the inside of arteries.
- How well your arteries perform depends on a series of complex interactions which includes age, disease, lifestyle and genetics.

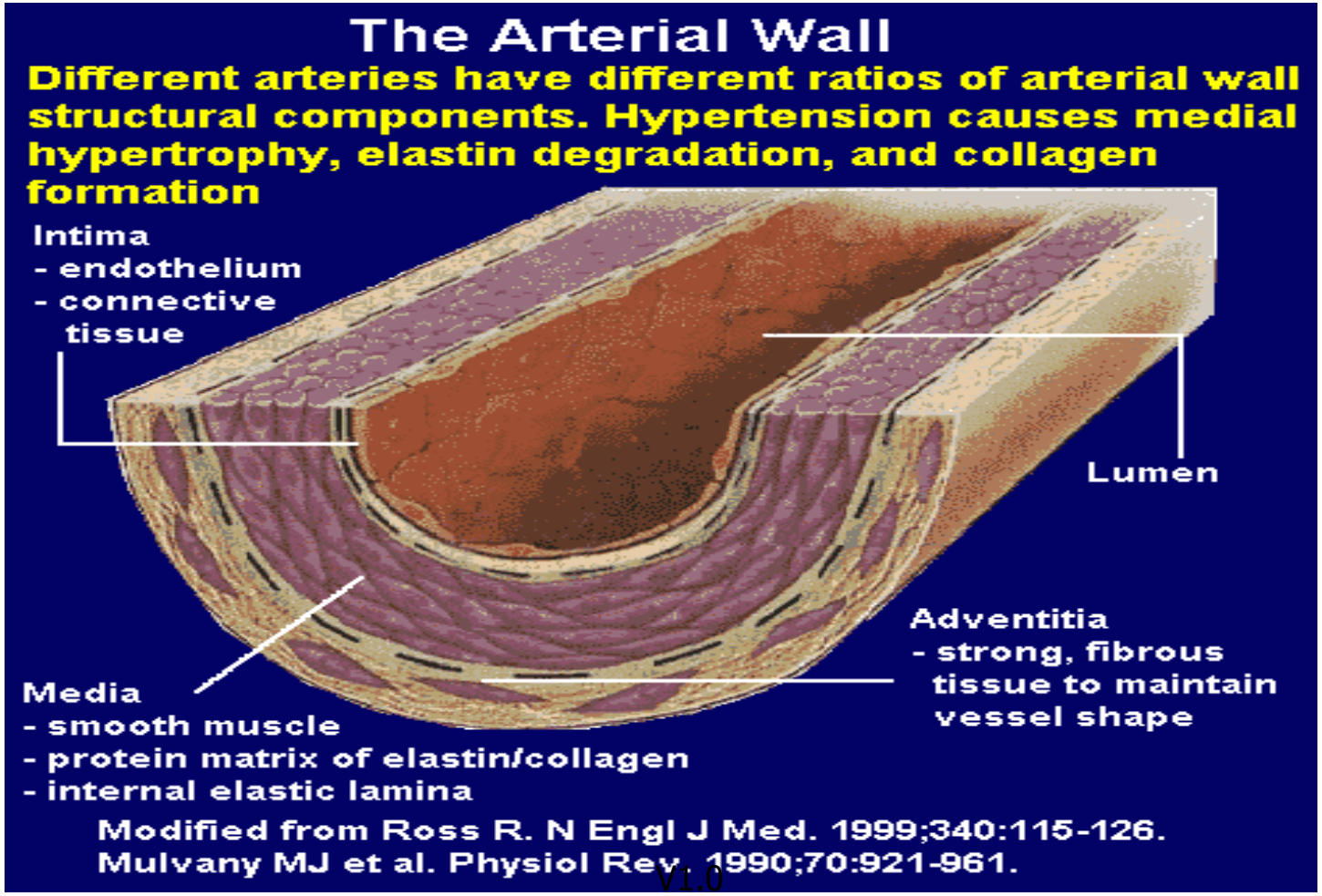
The Arterial System

- The good news is that studies strongly suggest that exercise, good nutrition, and emerging drug and nutraceutical therapies can slow the aging of arteries – even among people who are genetically at risk.

- These interventions could delay or prevent the onset of cardiovascular disease in many older people.

- It is imperative to find out the health of your arteries before clinical disease sets in and appropriate measures can be taken.

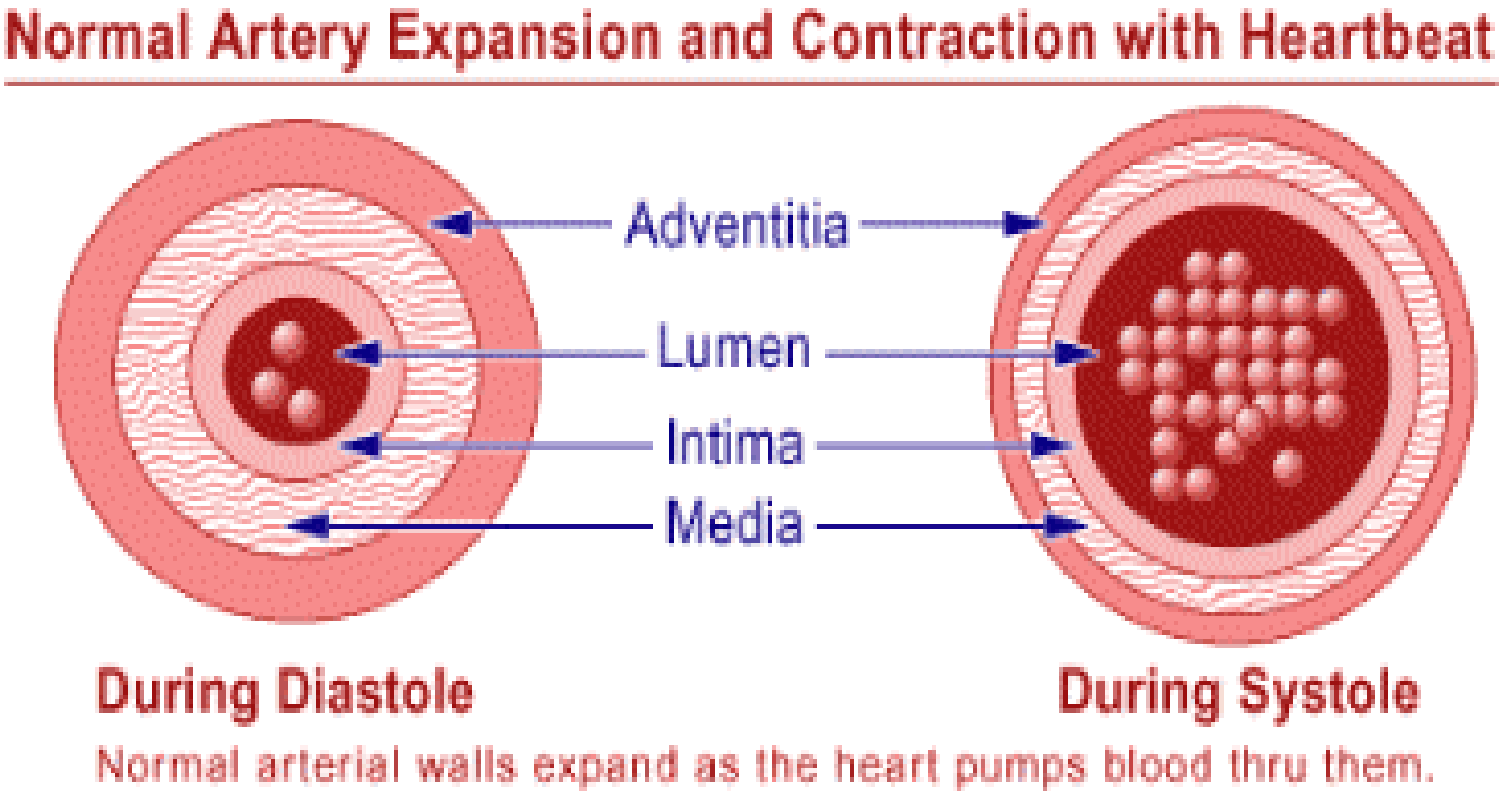
Inside Every Artery



Inside Every Artery

- Vessels that bring oxygenated blood from the heart (left ventricle) to the body and organs.
- The artery has 3 components – the intima, the media, and the adventitia.
- The opening through which the blood flows is called the lumen.

Inside Every Artery



Inside Every Artery

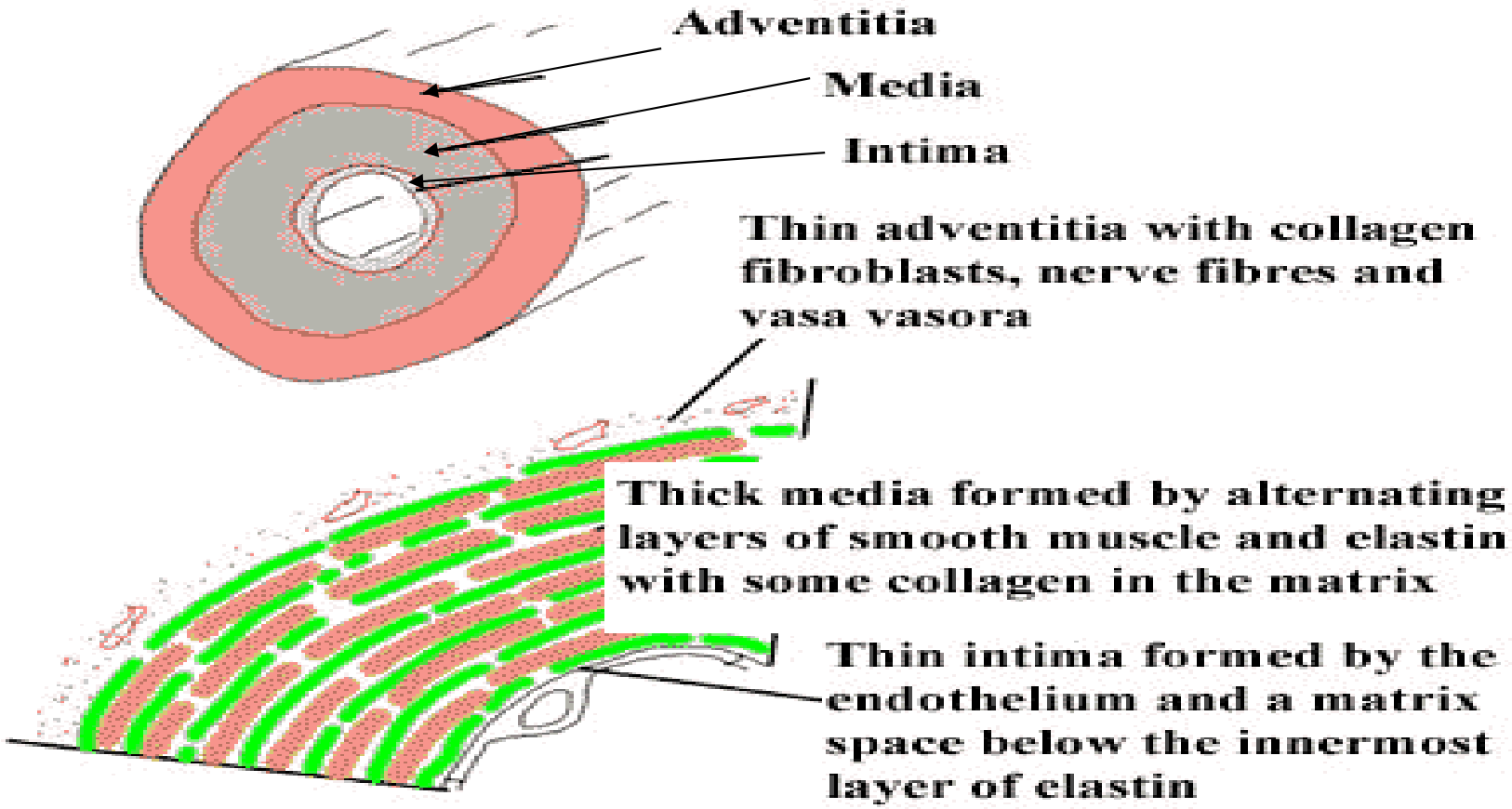
- ***Adventitia*** – outermost covering of the arterial wall which is composed of connective tissue and small blood vessels that feed the walls of the large arteries.

- ***Media*** – middle layer, made up of vascular smooth muscle cells, and surrounded by a network of fibers primarily made of two proteins, collagen & elastin.

- ***Intima*** – inner coat of the vessel (the part which is closest to the blood flowing within the artery) which consists of a single layer of specialized endothelium cells which line all blood vessels. The endothelial cells act as a barrier to prevent certain substances from entering the vessel wall through the intima.

Together, these three layers of artery wall surround the lumen, the opening that blood flows through on its journey throughout the body.

Adventitia, Media & Intima



Endothelium Review

- "Intima" consists of a single layer of cells, called endothelial cells – the endothelium
- Lines all blood vessels
- Can be considered a very large organ (*if spread out over a flat area, the endothelium would cover the approximate area of 3 football fields)*
- Poor endothelial function appears to be at the center of the atherosclerotic process

Endothelium Review

- The endothelium is the layer of thin, flat cells that lines the interior surface of blood vessels, forming an interface between circulating blood in the lumen and the rest of the vessel wall.
- Endothelial cells line the entire circulatory system, from the heart to the smallest capillary
- Endothelial cells are involved in many aspects of vascular biology, including:
  - vasoconstriction & vasodilatation, and hence the control of blood pressure
  - blood clotting (thrombosis & fibrinolysis)
  - atherosclerosis
  - formation of new blood vessels (angiogenesis)
  - inflammation and swelling (edema)

Endothelial Function

Endothelial Cells:

Produce Nitric Oxide (NO2) which diffuses into smooth muscle layer causing:

- Vasodilatation
- Inhibits platelet aggregation and the adherence of circulating blood cells to blood vessel walls
- Decreased monocyte (white blood cell) migration (into smooth muscle cells) which is the beginning of the atherosclerotic process

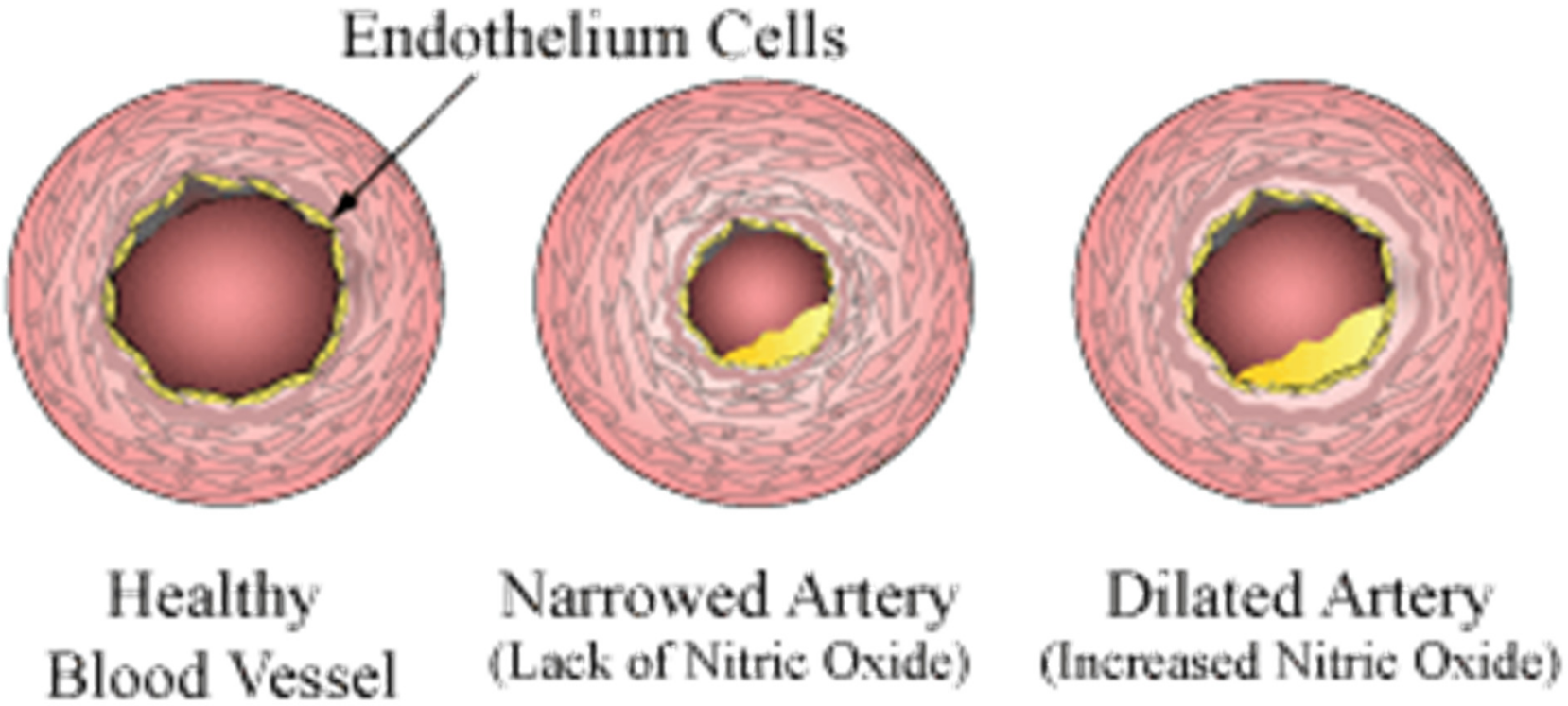
Endothelial Function – NO

Nitric Oxide:

- Relaxes arteries to help maintain normal blood pressure
- Increases oxygen supply
- Protects the heart from damage and cell death
- Mediator in inflammation
- Potent free radical scavenger

Robert F. Furchgott, Ph.D. New York, Louis J. Ignarro, Ph.D. of UCLA, and Ferid Murad, M.D., Ph.D. of the University of Texas at Houston won the 1998 Nobel Prize in medicine for their work on "Nitric Oxide as a Signaling Molecule in the Cardiovascular System"

Endothelium Cells



The Endothelium Maintains Vascular Health

Proper Endothelial Function

- Dilation
- Growth Inhibition
- Antithrombotic
- Anti Inflammatory
- Antioxidant

Endothelial Dysfunction

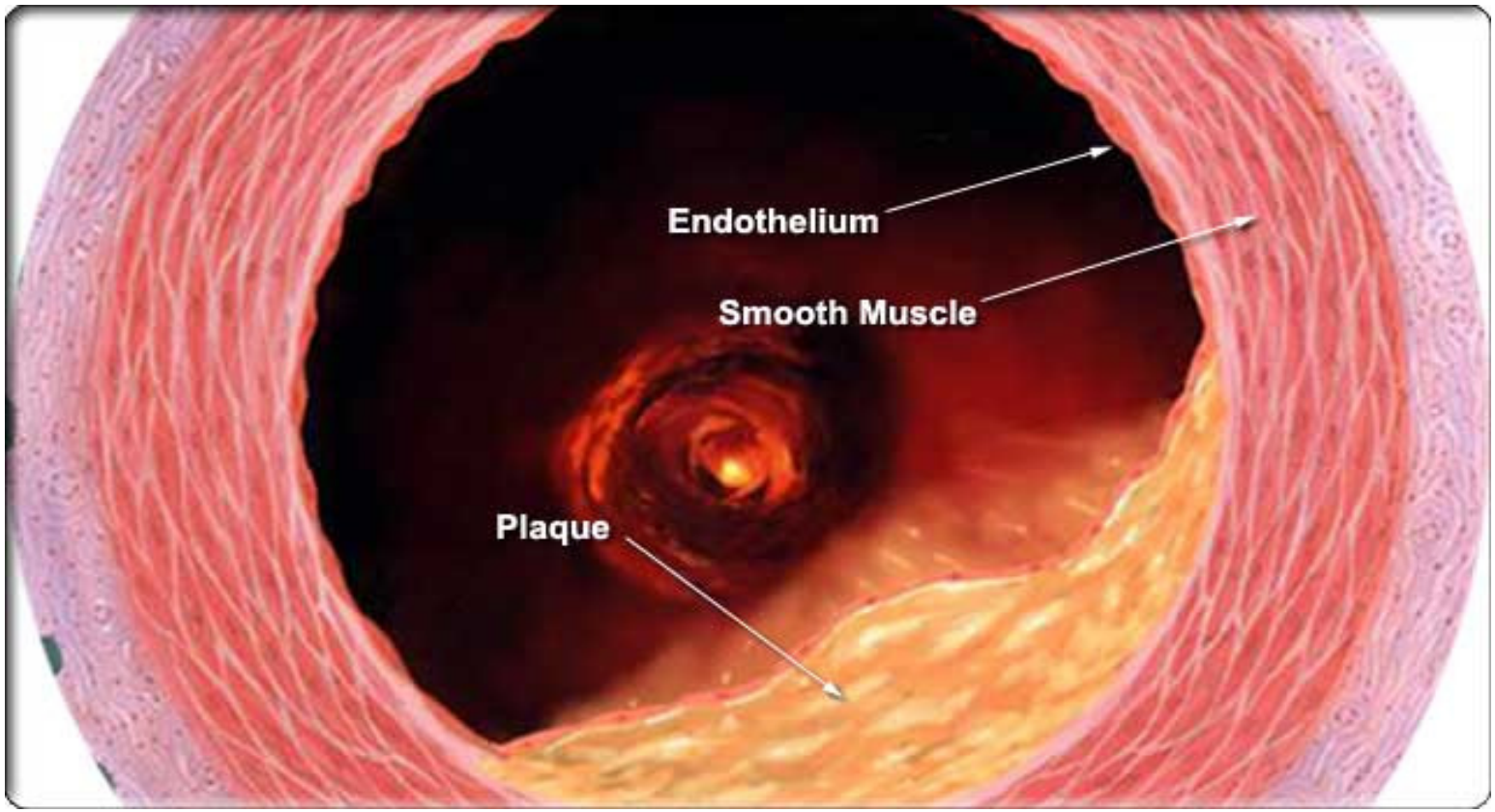
- Constriction
- Growth Promotion
- Prothrombotic
- Pro-inflammatory
- Pro-oxidant

Endothelial Damage

When Endothelium is Damaged:

- Blood vessels lose elasticity
- Arterial walls thicken
- Plaque formation begins
- Early arteriosclerosis can progress to advanced atherosclerosis

Endothelium – Plaque Buildup



Early arteriosclerosis can progress to advanced atherosclerosis

Arteriosclerosis

Greek word for “hardening of the arteries”

- A general term for which the arterial wall becomes thickened and loses elasticity. Can become as *"stiff as a lead pipe*."
- It is believed that the build up of plaque is initiated by free radical damage to the artery wall. Free radicals mutate the DNA of arterial cells, causing them to replicate themselves many times over.
- The proliferating cells form, in effect a mini-tumor in the artery wall. This tumor-like growth expands, stretching and tearing the inner lining of the artery.
- Arteriosclerosis can remain undetected for many years. In fact nearly half of all people in the western world who die from cardiovascular related illnesses never experience any prior symptoms!

Arteriosclerosis

- The blood lays down fibrin to patch the tears. Minerals and debris circulating in the blood become trapped in the patch.
- Because of opposing electromagnetic charges, the trapped minerals attract fats, including cholesterol. This cholesterol serves two purposes:

(1) It gives the patch a slippery surface so that blood cells can glide past it, and

(2) It acts as an antioxidant of last resort by donating electrons to neutralize free radicals, thus itself becoming oxidized in the process.

- Cholesterol is one of the last ingredients to form plaque, not the first.

Atherosclerosis

- Greek words: “athero” meaning gruel or paste “sclerosis” meaning hardness
- Name of the process in which deposits of fatty substances, cholesterol, cellular waste products, calcium, and other substances build up in the inner lining
- Build-up is sometimes called “plaque”
- Usually affects the large and medium-sized arteries

Atherosclerosis

Inflammation is a key factor in the development of Atherosclerosis:

- As LDL cholesterol accumulates in the arterial wall, it undergoes chemical changes and signals to endothelial cells to latch onto white blood cells circulating in the blood.
- These immune cells penetrate the intima and trigger an inflammatory response, devouring LDL's to become fat-laden "foam cells"
- These cells form a fatty streak, ***the earliest stage of atherosclerotic plaque***.
- Plaque is a combination of cholesterol, other fatty materials, calcium and components that stick to the artery wall lining.
- As an artery becomes more and more narrowed, less blood can flow through and the artery may also become less elastic.

Atherosclerosis

- Most plaque buildup occurs in medium to large arteries. Interestingly, atherosclerosis is a slow, progressive condition that often starts in childhood and by age 65 affects 1 out every 2 adults.
- This process begins with changes to the endothelium (the innermost layer of the artery).
- These changes cause white blood cells to stick to the endothelial cells, weakening the barrier between the endothelium and other layers of the artery.
- This allows fats, cholesterol, calcium, platelets, and cellular debris to accumulate in artery walls.
- Plaques have various sizes and shapes. Some plaques are unstable and can rupture or burst. When this happens it causes blood clotting inside the artery. If a blood clot totally blocks the artery, it stops blood flow completely.

Atherosclerosis

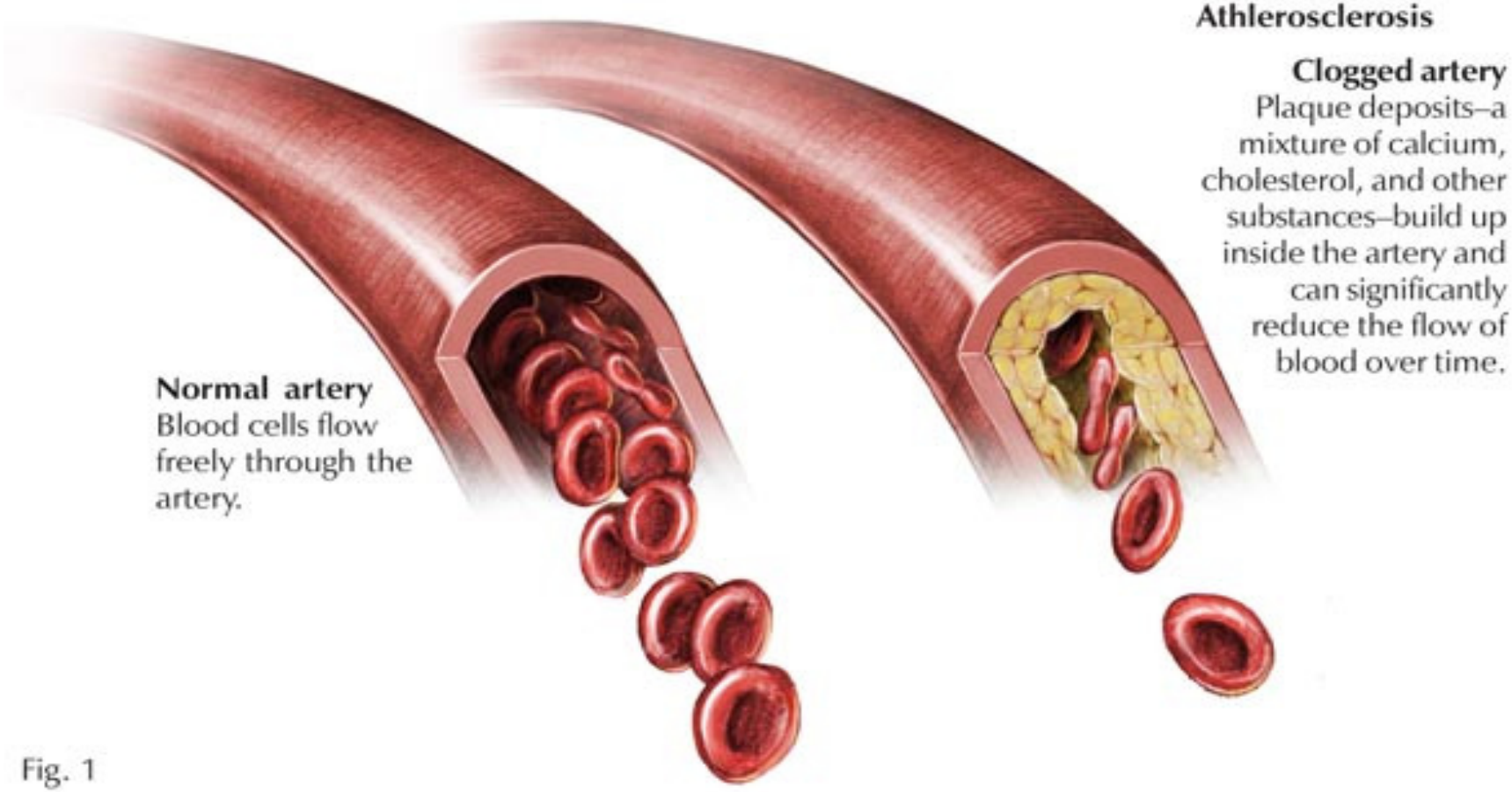
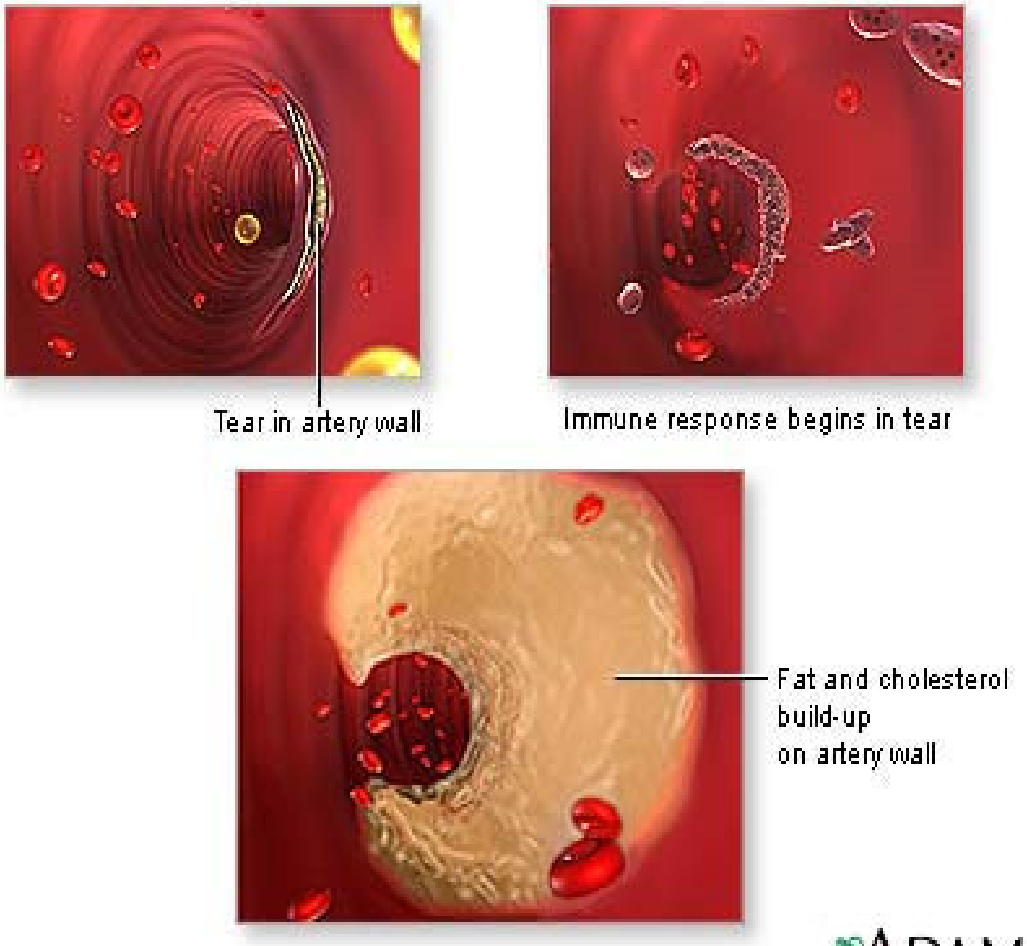


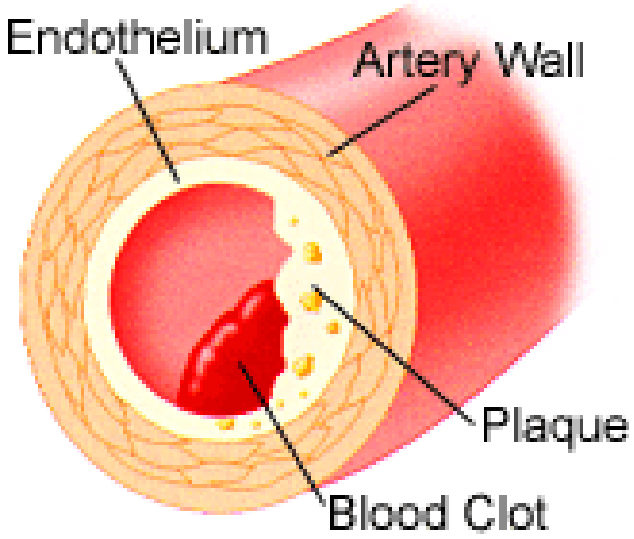
Fig. 1

Atherosclerosis

- Plaques can grow large enough to significantly reduce blood flow
- Most of damage occurs when arteries become fragile and rupture
- Plaques that rupture cause blood clots to form that can block blood flow *or* break off and travel to another part of the body



Atherosclerosis

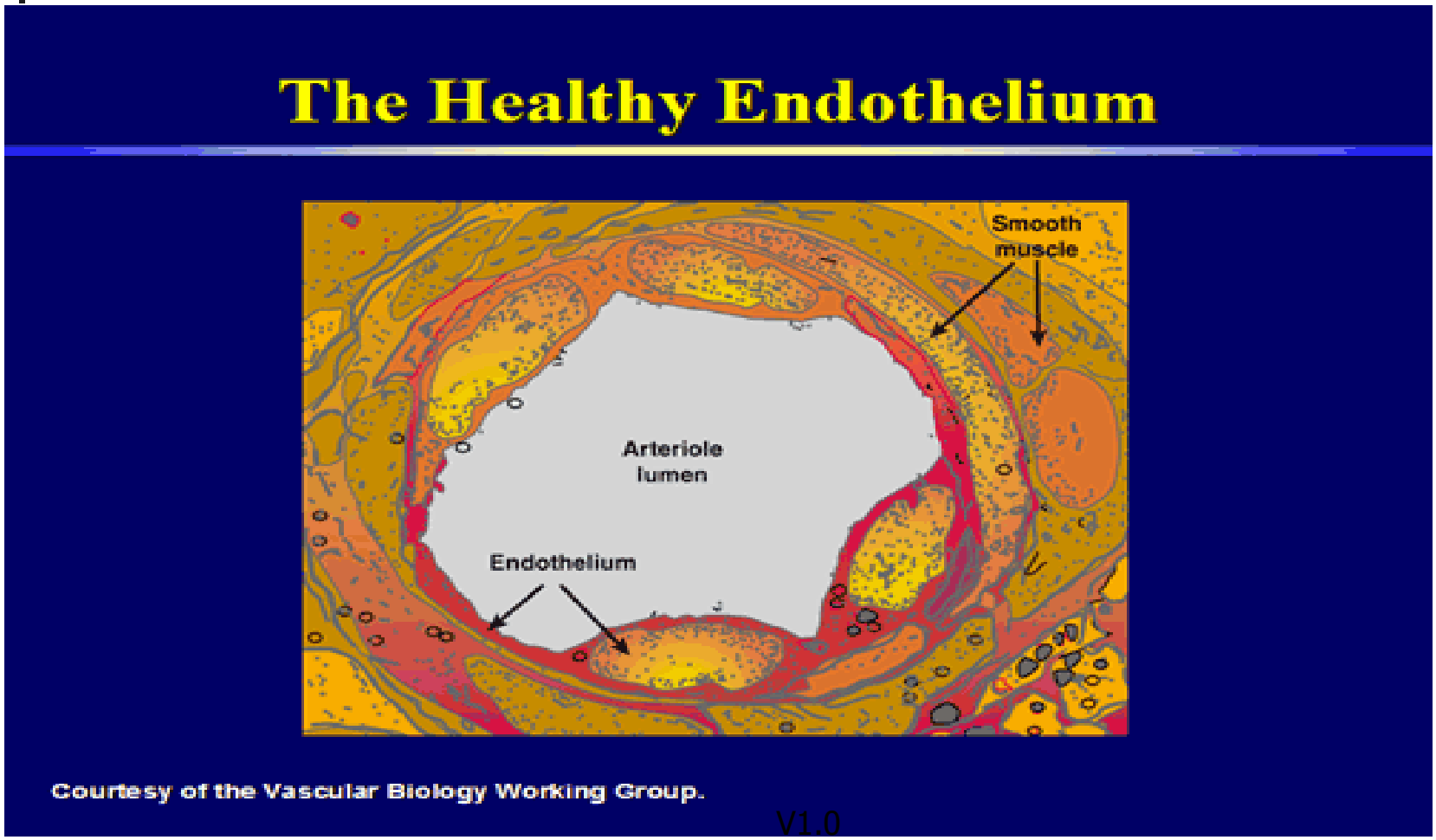


Diseased Artery

There are a number of risk factors, such as smoking, high blood pressure, and high cholesterol. The more risk factors you have, the more likely that you have Atherosclerosis

This is what happens in most heart attacks and strokes. There are usually no symptoms, such as pain until one or more artery is so clogged with plaque that blood flow is severely reduced.

The Healthy Endothelium



The Healthy Endothelium

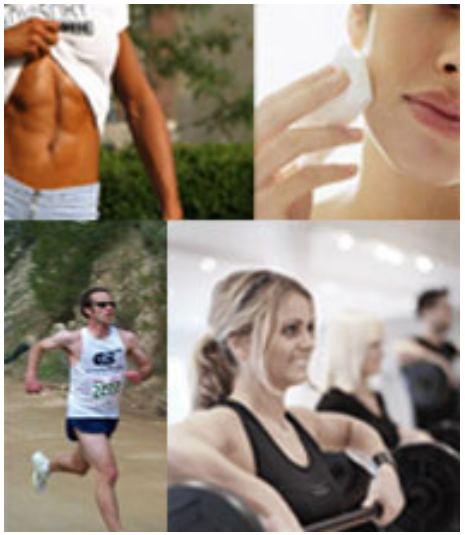
- Healthy endothelial cells produce nitric oxide, an important signaling molecule that helps keep arteries supple.
- When nitric oxide enters a cell, it stimulates a biochemical process that relaxes and dilates blood vessels.
- Nitric oxide also keeps atherosclerosis in check by preventing platelets and white blood cells from sticking to the blood vessel walls.
- The molecule can also curb the abnormal growth of vascular muscle, which can thicken blood vessel walls.

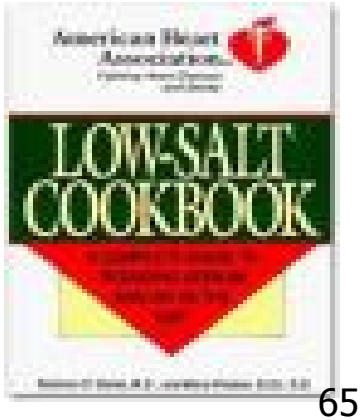
The Healthy Endothelium

- Even if sufficient amounts of nitric oxide are produced it can still be inactivated by oxygen free radicals – which are unstable molecules that injure vascular tissue.
- Without adequate levels of biologically available nitric oxide, endothelial cells in the intima can't function properly.
- Some researchers consider decreased availability of nitric oxide in the endothelium to be one of the earliest signs of arterial aging and high blood pressure.
- In addition, those at high risk of developing heart disease or have heart disease produce a modified amino acid called asymmetric dimethylarginine (ADMA).

Endothelium Health

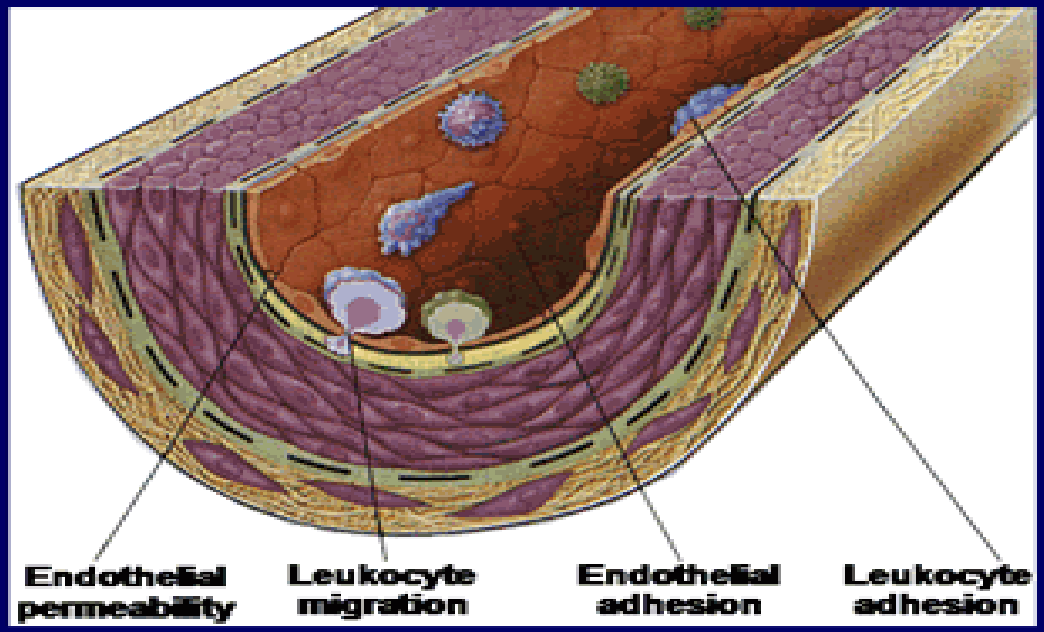
People who maintain a healthy endothelium as they get older and make an effort to do things that promote the repair of injured endothelium can reduce the risk of heart attacks and strokes caused by atherosclerosis or hypertension.





The Dysfunction Endothelium

The Dysfunctional Endothelium



Ross R. *N Engl J Med.* 1999;340:115-126.

The Unhealthy Endothelium

Asymmetric Dimethylarginine (ADMA)

- ADMA is a modified amino acid that can block the production of NO. Similar in structure to L-Arginine, ADMA can fit into the NOS enzyme, but because it has two extra methyl groups, it can't be made into NO.
- "Many different researchers around the world have found that blood levels of ADMA were elevated in people with each of the risk factors for heart disease: high cholesterol, high triglycerides, high blood pressure, insulin resistance, high homocysteine, and tobacco use." (The Cardiovascular Cure, John P. Cooke, M.D., Ph.D. and Judith Zimmer)

The Unhealthy Endothelium

Asymmetric Dimethylarginine (ADMA)

- *The level of ADMA is a better predictor of endothelial impairment than the level of cholesterol*.
- *ADMA accumulates in people with risk factors, blocking the production of NO, causing poor blood flow and contributing to hardening of the arteries*.
- *L-Arginine along with anti-oxidants can improve the body's ability to get rid of ADMA*
- *Most people simply are not producing enough nitric oxide*

(The Cardiovascular Cure, John P. Cooke, M.D., Ph.D. and Judith Zimmer)

Aging Arteries

Biochemical changes can lead to structural breakdowns in the aging arterial wall

- With age, some smooth muscle cells in the media die causing the remaining ones to work harder and grow larger.
- Over time, other alterations cause some smooth muscle to stop contracting as usual.
- The cells then begin producing excessive amounts of proteins and other matrix substances which creates an imbalance of elastin & collagen in the media.
- Collagen strands turn brown, become cross linked and less supple, while elastin becomes overloaded with calcium, stretches out and eventually ruptures further eroding flexibility.

Solutions for Healthy Arteries & Cardiovascular health

- **L-Arginine (5 grams minimum)**
- Antioxidants
- Omega-3 fatty acids
- Phytoestrogens
- B Vitamins
- Exercise
- Stop Smoking!
- Healthy diet

A study reported in *Circulation* concluded that treatment with L-arginine produced a fourfold increase in blood vessel dilation from 2.2% to 8.8%. (Hambrecht et al., 2000)

Functional Measurement

- How do we measure the health of the endothelium in a real-time, non-invasive manner?
- How can we measure effectiveness of treatment choices and lifestyle changes?

***Name*_____**

Part I Quiz

UNDERSTANDING CARDIOVASCULAR & ARTERIAL HEALTH

1. Instead of prescribe, use the word _____.

2. Instead of treat, use the word _____.

3. Instead of disease, use the word _____.

4. Instead of cure, use the word _____.

5. Instead of diagnose, use the word _____.

6. It is okay for me to tell my client to stop taking what medicine?

a) Cholesterol Drugs
b) High blood pressure drugs
c) Aspirin and other NSAIDs
d) All of the above
e) None of the above

7. Which is NOT a form of cardiovascular disease?
   a) Hypertension
   b) Congestive Heart Failure (CHF)
   c) Coronary Artery Disease (CAD)
   d) Obesity
   e) Sexual Dysfunction (ED)
8. Which is NOT a true statement about cardiovascular disease?
   a) It is the leading cause of death in men and women.
   b) It is the second only to cancer in claiming lives.
   c) It represents more than 30% of all deaths worldwide.
   d) It causes more than 1 million deaths in the U.S.
9. According to the America Heart Association, which of the following is NOT a risk factor for cardiovascular disease?
   a) Smoking
   b) Obesity
   c) Diabetes
   d) Triglycerides
   e) High Blood Pressure
10. The heart beats about:
   a) 100,000 times per day
   b) 59,650 times per day
   c) 78,000 times per day
   d) 1 million times per day

11. The proportion of blood that is pumped out of the heart during each beat compared to the amount that remains in the heart at the beginning of the next beat is called:

a) Blood Pressure
b) Stoke Volume
c) Heart Dynamics
d) Ejection Fraction

12. Which is NOT a major cause of high blood pressure?

a) Salt
b) Narrowing of the arteries
c) Greater than normal volume of blood
d) Heart beating faster

13. The diastolic pressure is the top number and the systolic pressure is the bottom number.

a) True
b) False

14. A normal blood pressure reading is:

a) 110 / 70
b) 120 / 80
c) 130 / 90
d) 140 / 80

15. High blood pressure is diagnosed in more than 40% of:
    a) Caucasians
    b) Asians
    c) Latinos
    d) African Americans
16. Which is NOT one of the three components of an artery?
    a) Adventitia
    b) Intima
    c) Lumen
    d) Media
17. When the endothelium is spread out it can cover:
    a) A ping-pong table
    b) A hockey rink
    c) 2 Soccer fields
    d) 3 Football fields
18. What is the endothelium?
    a) The outermost covering of the arterial wall, which is composed of connective tissue and small blood vessels that feed the walls of the larger arteries.
    b) The cells that carry cholesterol from the blood back to the liver, which processes the cholesterol for elimination from the body.
    c) The layer of thin, flat cells that lines the interior surface of blood vessels (intima), forming an interface between circulating blood in the lumen and the rest of the vessel wall.
    d) How should I know . . . I can't even pronounce it!

19. Which is NOT a function of the endothelium?
a) Vasoconstriction / Vasodilation
b) Anti-bacterial
c) Blood clotting
d) Inflammation
20. Which is NOT a description of Nitric Oxide?
a) A Liquid
b) A Gas
c) NO
d) Short lived
21. When endothelium is damaged, what does NOT happen?
a) Plaque formation begins
b) Blood vessels lose elasticity
c) Develop acid reflux
d) Arterial walls thicken
22. Which is NOT a true statement about arteriosclerosis?
a) Is defined as hardening of the arteries
b) Another term for blood vessels losing their elasticity
c) Can lead to atherosclerosis
d) Is very symptomatic

23. Which is NOT a true statement about atherosclerosis?

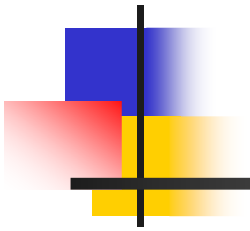
a) Affects all the arteries
b) Is also referred to as plaque
c) It is a build-up of substances in the inner lining of arteries
d) Comes from the Greek words meaning hardened and paste

24. Which is NOT a true statement about Asymmetric Dimethylarginine (ADMA)?

a) The level of ADMA is a better predicator of endothelial impairment than the level of cholesterol.
b) Researchers have discovered that blood levels of ADMA were lower in people with each of the risk factors for heart disease.
c) L-Arginine along with anti-oxidants can improve the body's ability to get rid of ADMA.
d) ADMA is a modified amino acid that can block the production of nitric oxide.

25. Which is NOT recommended for improving cardiovascular health?

a) Arginine
b) Exercise
c) Healthy Diet
d) Trans Fatty-3 Acids
e) Stop Smoking



Part 2

Understanding Pulse Wave Analysis

Goals

- To understand pulse wave analysis and how it relates to arterial compliance

Arterial Pulse Wave Analysis

Screening risk factors by early detection of abnormal arterial-wall function.

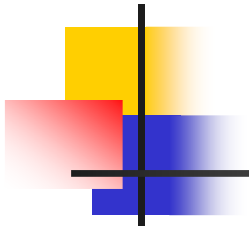
- Identifying the arteriosclerosis & arterial aging.
- Monitoring the effect of treatments for patients with hypertension and other cardiovascular disease.
- Evaluating the efficacy of prescribed lifestyle modification and medications.

Arterial Compliance (Elasticity)

- "Hardening of the Pulse" – first described thousands of years ago by Chinese healers
- Arterial stiffness is an emerging major risk factor for cardiovascular morbidity and mortality
- Arterial compliance variables depend upon the distending pressure in the vessel

Arterial Stiffness

- Arterial stiffness is a major cause of CVD.
- Increases in arterial stiffness increase central systolic & pulse pressure, and demand on the left ventricle
- Increasing the risk of heart attacks, heart failure and stroke.



Pulse Wave History

- Pulse Wave Analysis was used over 130 years ago as an important part of the medical exam
- Graphic methods for clinical pulse wave recording were introduced in the 1800's
- Replaced by the sphygmanometer
- Recent years there has been a resurgence of interest

Pulse Wave History

Due to software and more sophisticated devices, it is now possible to generate indices of ventricular-vascular interaction:

- Pulse Wave Analyzers can show the efficacy of lifestyle modifications, such as diet, exercise, supplementation and pharmaceutical drugs.
- Individuals respond to the powerful visual readout and can be a great motivator for preventative health!

Pulse Wave Analysis

Non-invasive, repeatable, reliable, affordable, functional method of measuring:

Baseline data

Follow-up data

What Is a Pulse Wave?

- Tells a story on how the blood travels through large arteries through to the peripheral arteries.
- Ejection of blood from the left ventricle during systole initiates an arterial pressure wave that travels towards the periphery.
- A Pulse Wave Analyzer can measure in a non-invasive, repeatable, and reliable way, and is a functional method to measuring baseline data and follow-up data.

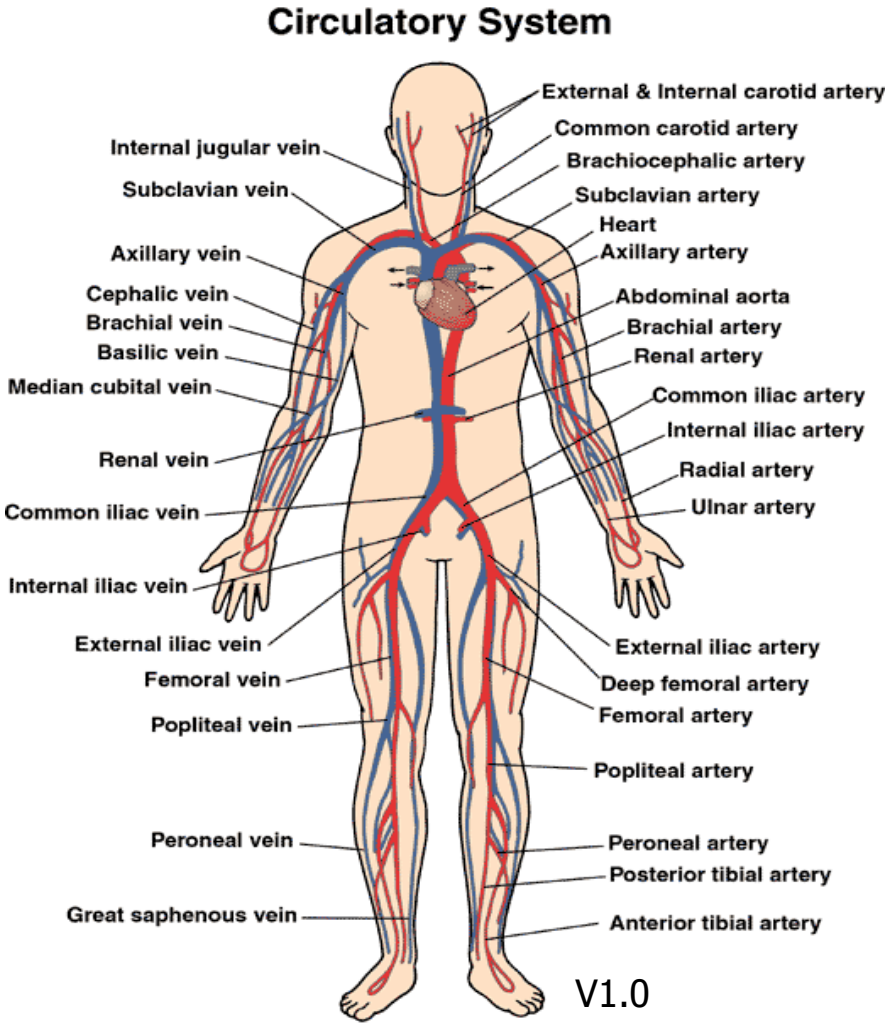
Pulse Wave Defined

AS THE HEART BEATS, pressure and flow pulse waves travel away from the heart and are reflected back toward the heart from various locations in the arterial system.

Understanding Pulse Wave Analysis

- Arterial stiffness occurs at varying rates in different people.
- In a large scale study involving 3,075 healthy older people, those who had the highest pulse wave velocity were three times more likely to die of cardiovascular disease than those who had the lowest pulse wave velocity. *(National Institutes of Health/National Institute on Aging/US Department of Health and Human Services)*
- It is becoming more apparent that changes in the aging circulatory system, even those without outward symptoms, precede and predict a higher risk of developing cardiovascular diseases.

Circulatory System

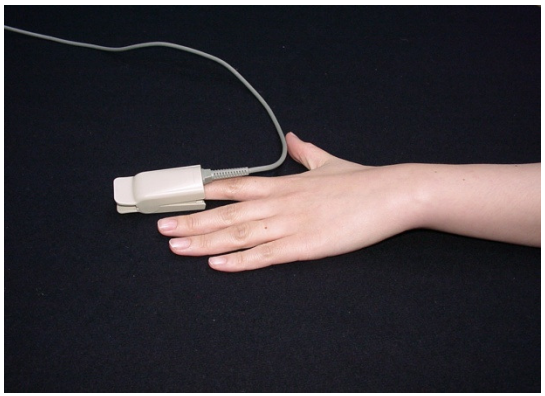


Pulse Wave

- Aging and disease states associated with an increase in cardiovascular events alter the physical characteristics of blood vessel walls and impair the pulsatile function of the arteries.
- An accumulating body of evidence indicates that impaired pulsatile function of arteries provides important prognostic and therapeutic information beyond that provided by traditional blood pressure measurements.

Pulse Wave Analyzers

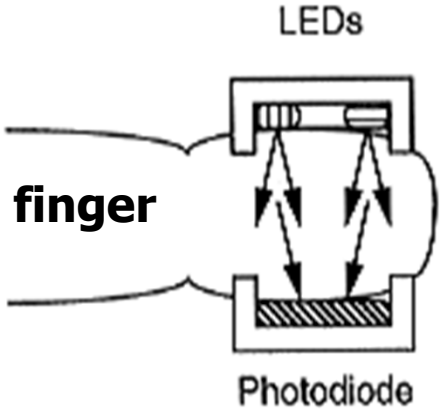
- Use a finger-probe similar to a pulse oximeter



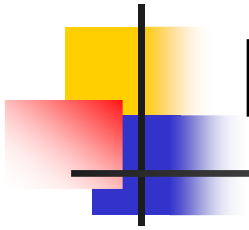
- Use light sources:

  Light-emitting diodes – shines visible red and infrared light into the fingertip

Principle of Measurement



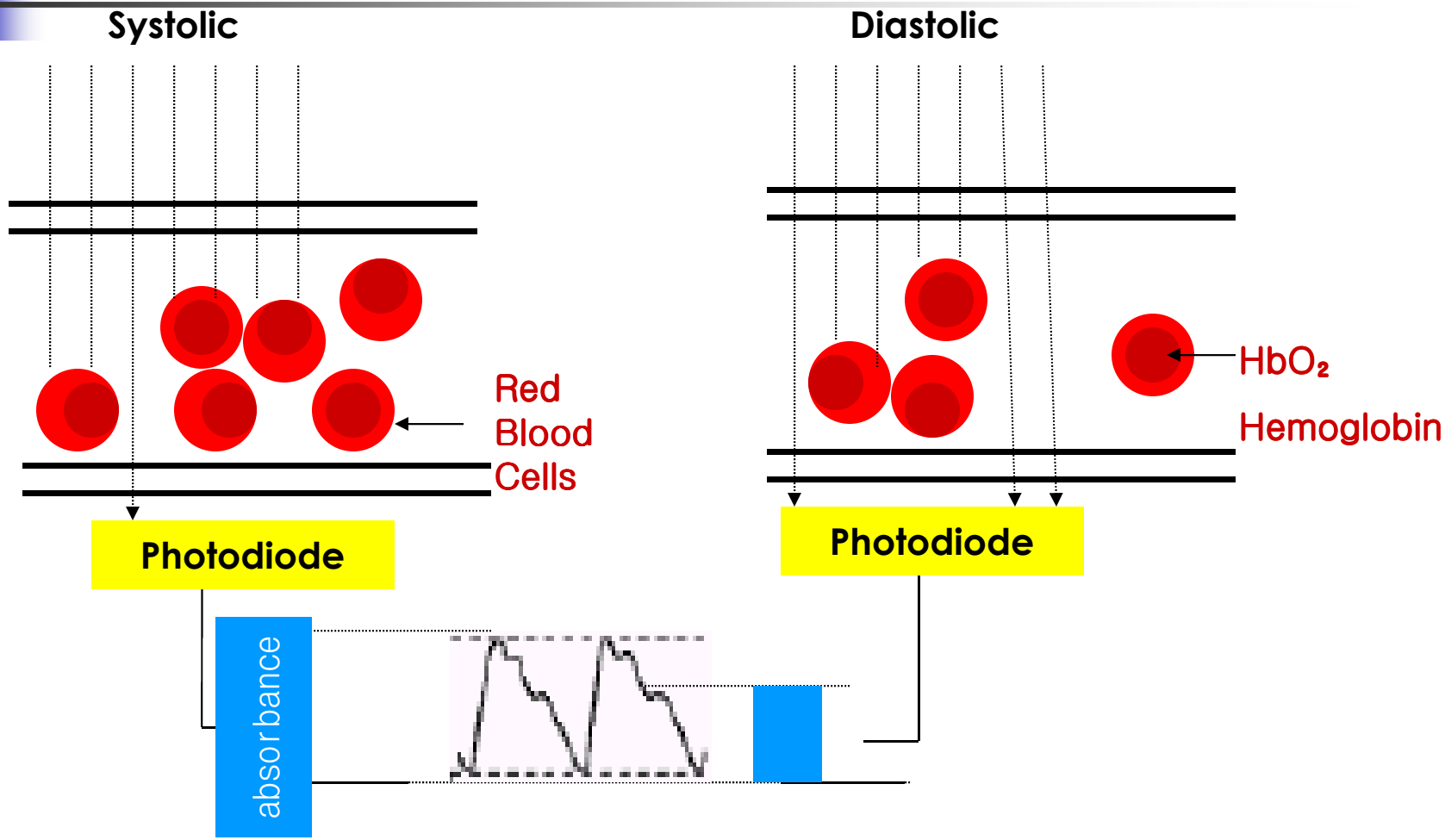
The light from the LEDs is transmitted through the tissue at the sensor site. The Photodiode detects the changes in the amount of light absorbed by hemoglobin, which forms a PTG.



Finger Tip Probe

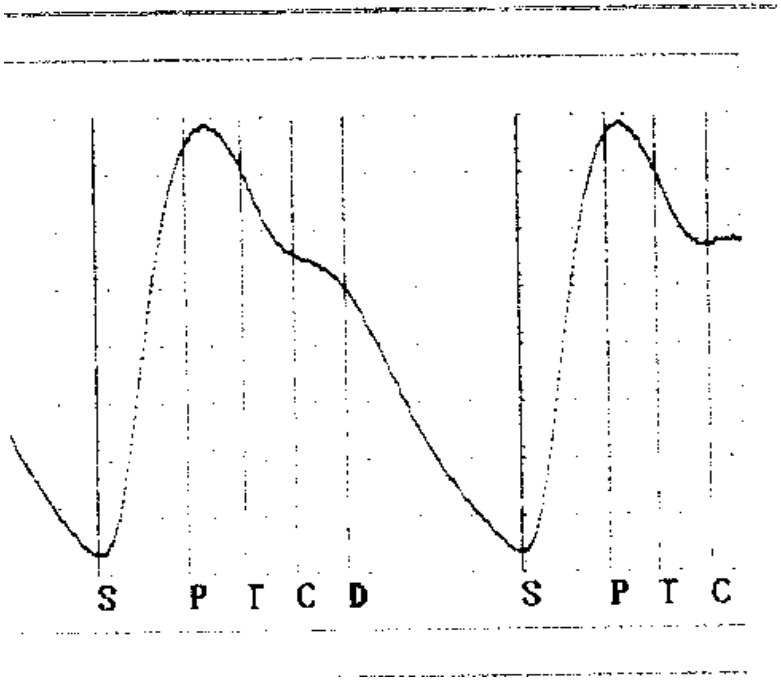
- A photoplethysmograph is an optical detector that indicates the volume of blood in or passing through an area of tissue.
- By placing the photoplethysmograph at or near the site of a human artery the pulse waveform can be detected and measured

Principle of Measurement



What is a Plethysmograph Waveform?

The arterial pulse waveform results from the ejection of blood from the left ventricle and moves with a velocity much greater than the forward movement of the blood itself



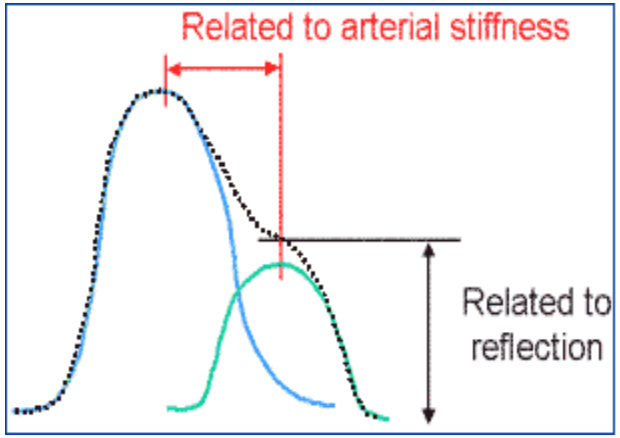
Pulse Waveform

1st part of waveform (systolic component) result of pressure transmission along a direct path from the aortic root to the finger

(aortic root =the dense fibrous area that encircles the aortic valve and constitutes the junction between the left ventricle and the aorta.)

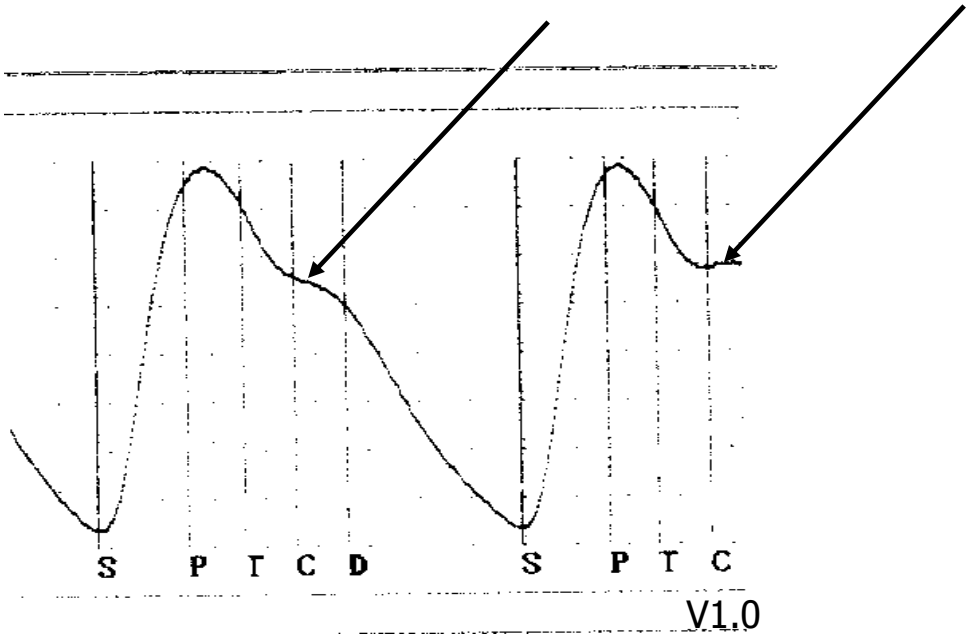
Pulse Waveform

2nd part (diastolic component) is formed by pressure transmitted from the LV along the aorta to the lower part of the body where it is reflected back along the aorta to the finger.



Pulse Waveform

- The height of the diastolic component of the PW = amount of pressure wave reflection.
- Relates mainly to the tone of small arteries.



Pulse Waveform

- The timing of the diastolic component relative to the systolic component depends on how fast the wave passed through the aorta and large arteries

- The stiffer the arteries the quicker the blood and waveform passes through

Understanding Pulse Wave Analysis

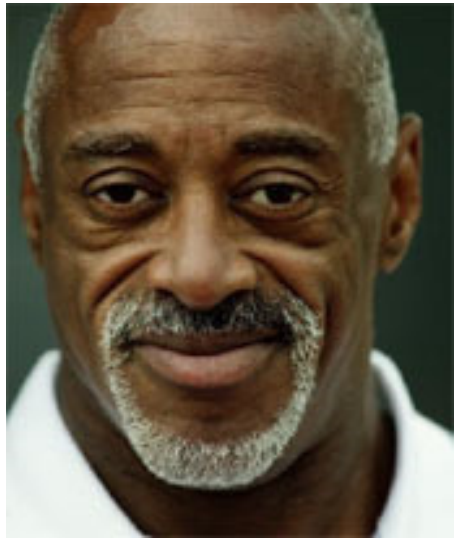
- Client: healthy 25-year old male
- The arterial walls are smooth, slick and compliant.
- The heart contracts, the aortic valve opens and blood is pumped into the aorta (largest artery in the body) and flows up toward the neck, where the carotid artery branches off to take blood to the head and brain, and then down toward the rest of the body.

Understanding Pulse Wave Analysis

- When the aorta receives the rushing pulse of blood from the heart, it also receives pressure spreading from the walls of the heart to its own walls.
- This pressure travels along the aorta's walls in wave after wave until it reaches the walls of the smaller branching arteries that take blood to the rest of the body.
- There, the speed of these pressure waves – known as pulse wave velocity – slows, and some are sent back through the aorta walls, becoming what are known as ***WAVE REFLECTIONS***

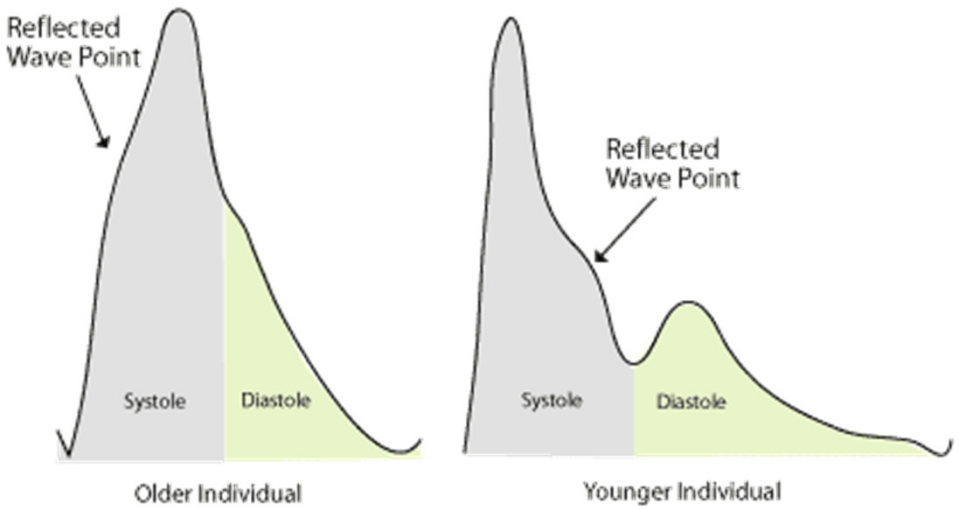
Understanding Pulse Wave Analysis

- Now add 50 years to this picture: the arteries, including the aorta, grow stiffer and dilate, their walls becoming thicker, their diameter larger.
- As a result, the arteries no longer expand and contract as much as they used to.
- Along the walls of the stiffer aorta, the pressure waves move more rapidly, and as a result the reflection waves occur sooner than they did before.
- The timing of the reflection wave is how arterial stiffness is measured – non-invasively.



Understanding Pulse Wave Analysis

Notice the waveform of the older individual has no distinct dicrotic notch – demonstrating loss of elasticity

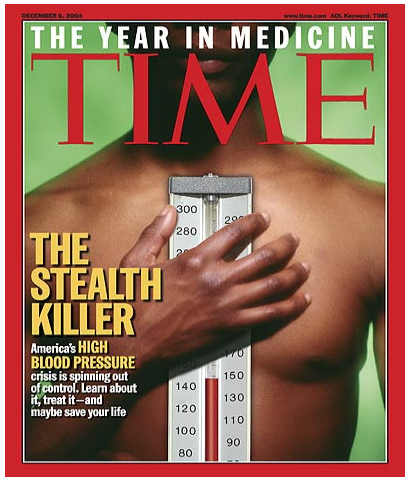


In an older person, the reflected wave arrives back at the heart while the heart is still in systole. This increases the amount of work necessary for the heart to pump, increases blood pressure, and decreases blood flow to the coronary arteries.

In a young person, the reflected wave arrives back at the heart as the contraction phase (Systole) ends and the relaxation phase (Diastole) begins. The reflected wave maintains diastolic pressure and promotes coronary blood flow.

Understanding Pulse Wave Analysis

- Aging and disease states associated with an increase in cardiovascular events alter the physical characteristics of blood vessel walls and impair the pulsatile function of the arteries.
- An accumulating body of evidence indicates that impaired pulsatile function of arteries provides important prognostic and therapeutic information beyond that provided by traditional blood pressure measurements.



Changes in the pulse wave form can often be seen prior to the onset of clinical symptoms such as high blood pressure and high cholesterol.

Interesting, many people have no idea of their blood pressure and cholesterol levels. Prevention is the key!

Understanding Pulse Wave Analysis

- Along the walls of the stiffer aorta, the pressure waves move more rapidly, and as a result, the wave reflections occur sooner than they did before.
- The timing of the wave reflection, in fact, is one of the effects of arterial stiffness that can be measured non-invasively.
- Epidemiological studies using these measures have determined that high aortic pulse wave velocity (aPWV) is an independent predictor of arterial stiffness and cardiovascular disease and death.

Understanding Pulse Wave Analysis

- As the walls of the large arteries become stiffer, diastolic blood pressure tends to drop and systolic blood pressure rises.
- The difference between these two numbers is called pulse pressure.
- High pulse pressure – **greater than 60 millimeters of mercury** – is associated with greater thickening and stiffening of arterial walls.

PTG Waveform

- "S" (Starting Point)

  Starting Point of arterial pulse wave. Aortic valve opens and the blood of the left ventricle is discharged

- "P" (Percussion Wave)

  Pulse wave caused from LV ejection that increases the arterial wall linearly (a sharp P point represents the maximum elasticity of the aorta - a "gentle" P point represents low elasticity, which is indicative of older arterial age

PTG Waveform

- "T" (Tidal Wave)

  Reflected wave from the small artery

- "C" (Incisura)

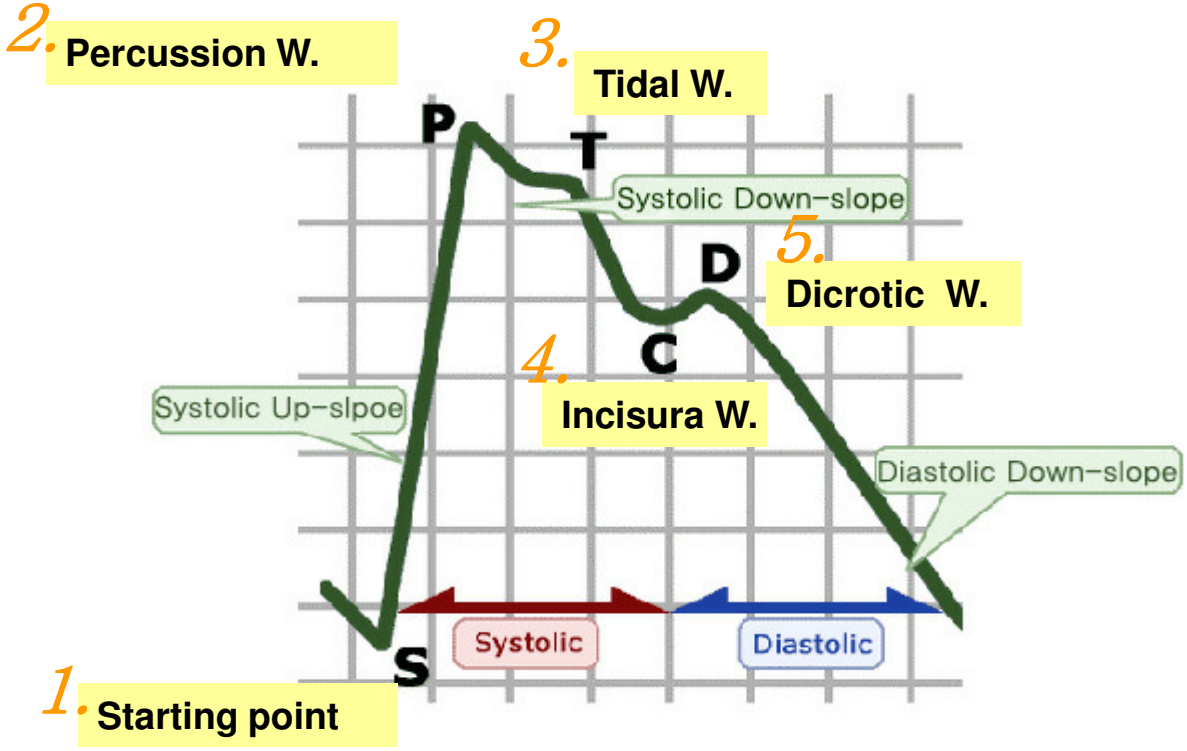
  End-point of systolic phase, then aortic valve is closed

- "D" (Dicrotic Wave)

  Reflective oscillatory wave occurred from the blood crash into aortic valve by flood pressure of aorta

Interpretation of PTG

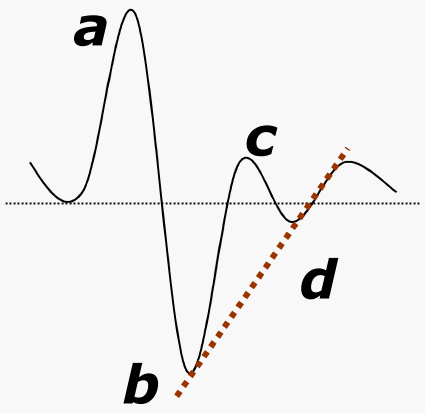
PTG (Plethysmogram) : Get directly from small arteries of fingertip, shows change of arterial blood volume



Accelerated Photoplythysomgraph Waveform (APG)

- The 2nd differentiation of PTG waves
- Analyze the blood circulation state, vascular elasticity and stiffness.
- The early analysis of lots of cardiovascular disease like a arteriosclerosis, peripheral circulation dysfunction

APG Waveform



- **a** The base value to compare easily at the wave observation
- **b Strength of cardiac output**
  The deeper (-) it goes from the middle line, the better the blood vessel
- **c Vascular elasticity**
  The higher (+) it goes from the middle line, the better the blood vessel.
- **d Remaining blood volume**
  The lower (-) it goes from the middle line, the better the blood vessel

** The gradient of b & d points determines the vascular state and aging processing*

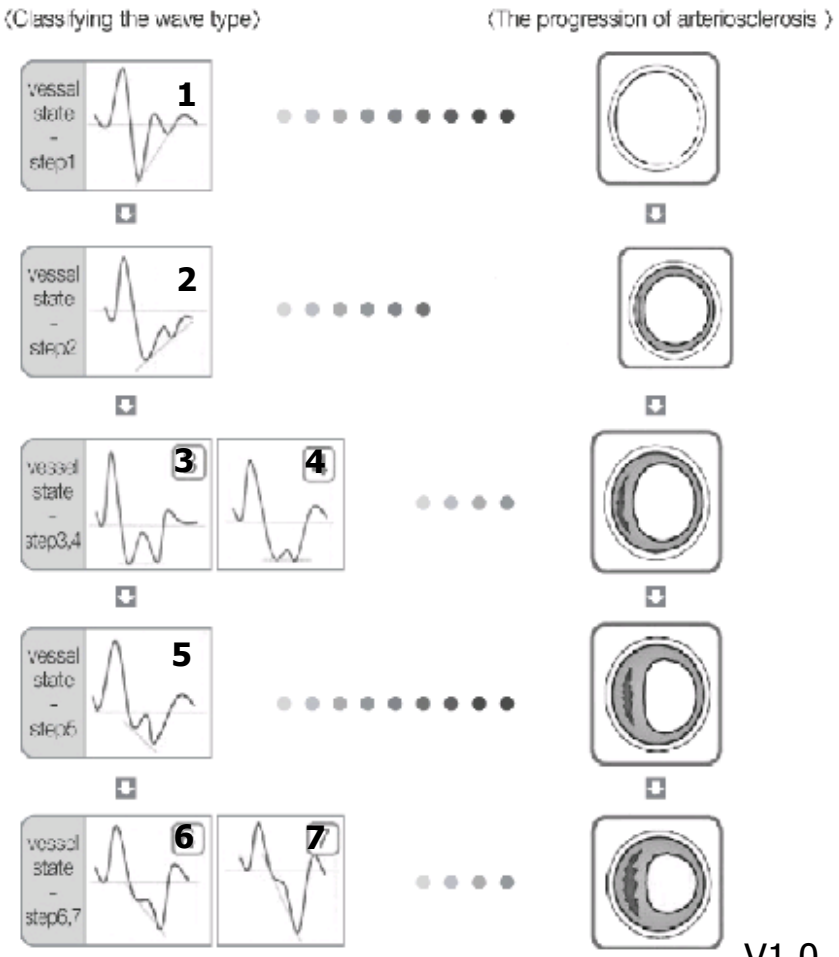
Cardiac-output intensity
Peripheral vascular elasticity
Remaining blood volume analysis

→ ***Vascular State*** →

Blood Circulation Dysfunction
Arteriosclerosis
Blood Vessel Aging

APG Waveform Analysis

7 types of vascular states



Blood circulation and blood vessels are good

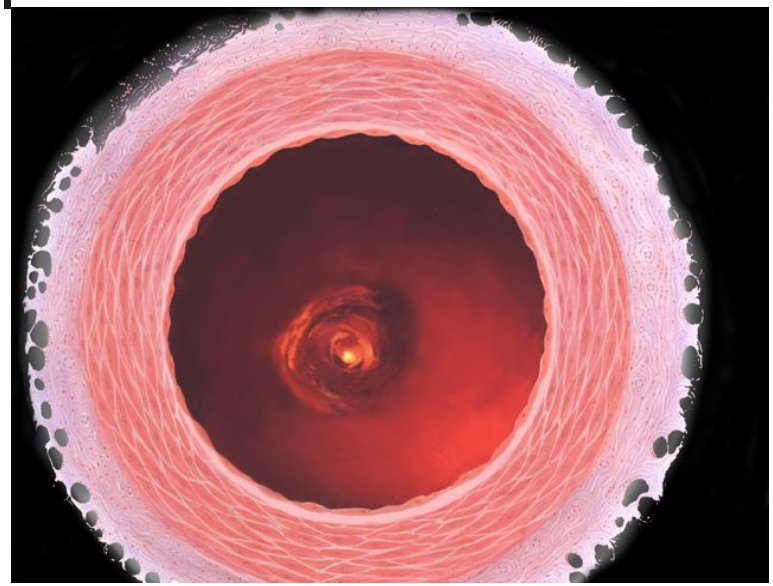
Current blood circulation and blood vessel are good, but may go bad

Start to get aged in the blood vessels

Not good blood circulation and getting aged in the blood vessels

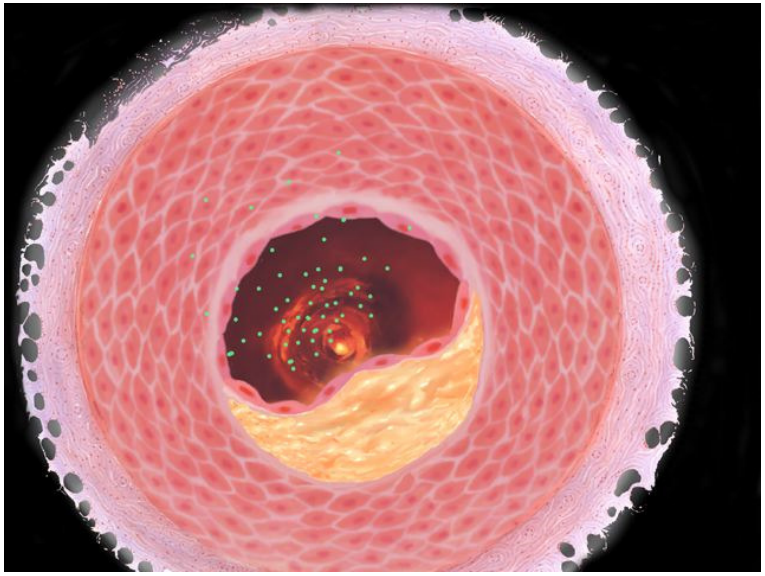
Blood circulation disorder and blood vessels dysfunctional

APG Waveform Analysis



Normal Blood Vessel

This vessel is a Type 1 and has no plague around the vessel



Abnormal Blood Vessel

This vessel has a lot of plague and vessel stiffness so it is a Type 6/7

Clinical Significance

- Measure peripheral blood circulation and the condition of the blood vessels
- Measure arteriosclerosis and degree of progression
- Prevent cardiovascular system dysfunction (myocardial infarction)
- Prevent cerebral vascular system dysfunction (cerebral infarction)
- Indicator of overall health = basic vital signs + HRV + APG
- Monitor progress of pharmaceutical & nutraceutical treatments, as well as lifestyle changes

How To Improve Biological Age?

- Increase exercise
- Proper diet
- Ideal weight
- Quit smoking and/or excessive drinking
- Nutraceuticals
- Pharmaceuticals
- Manage stress

***Name*_____**

Part II Quiz

UNDERSTANDING PULSE WAVE ANALYSIS

1. The purpose of a Pulse Wave analyzer is to:
   a) Identify arteriosclerosis and arterial aging
   b) Reverse cardiovascular disease
   c) Lower cholesterol
   d) Redistribute electromagnetic activity in the heart
2. Which statement is FALSE about pulse wave technology?
   a) Recently there is a resurgence of interest
   b) Dates back 130 years
   c) Replaces the stethoscope
   d) Clinical recording began in the 1800's
3. What type of waves travel away from the heart and are reflected back toward the heart from various locations in the arterial system?
   a) Red and Blue
   b) Pressure and flow
   c) Refractive and Reflective
   d) Tsunami and Tidal
4. What type of light is emitted by the light emitting diodes (LED) in the finger-probe?
   a) Low laser and white light
   b) UV and Laser
   c) Cold laser and fluorescent
   d) Red and Infrared

5. The photodiode or the bottom of the finger probe detects the changes in:

a) The amount of light absorbed by the hemoglobin
b) Blood pressure
c) Red blood cells
d) Pulse wave velocity

6. The arterial pulse wave results from the ejection of blood from the left ventricle and moves with a velocity much slower than the forward movement of the blood itself.

a) True
b) False

7. The first part of the pulse waveform is the:

a) Diastolic
b) Arterial pulse
c) Systolic
d) Ventricle pulse

8. When the arteries are stiff, the waveform passes through:

a) Quickly
b) Slowly
c) No difference
d) It can't pass through

Match the Wave with the definition.

9. S – Starting Point
10. P – Percussion Wave
11. T – Tidal Wave
12. C – Incisura
13. D – Dicrotic Wave

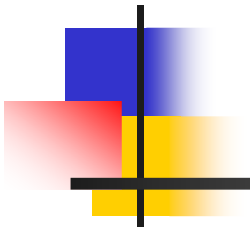
- Reflected wave from the small artery
- Reflective oscillatory wave occurred from the blood crash into the aortic wave
- Aortic valve opens and the blood of the left ventricle is discharged
- Pulse wave caused from LV ejection that increases arterial wall linearly
- End point of systolic phase, the aortic valve is closed

14. The loss of a dicrotic notch in the waveform indicates a loss in:

a) Pulse Velocity
b) Blood Pressure
c) Heart Rate
d) Arterial Elasticity

15. The true name for the finger probe is:

a) Digital Analyzing Light
b) Photoplethysmograph
c) Infrared Capacitor
d) Prostrate Exam



Part 3

Understanding Heart Rate Variability (HRV)

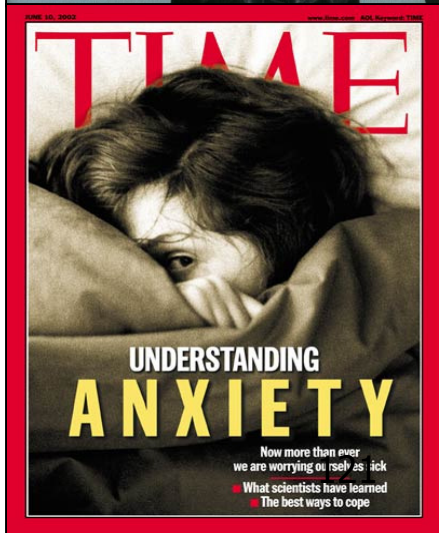
Stress & Heart Disease

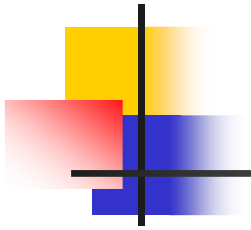
FACTS

- *50% of Heart Attack victims had normal cholesterol levels.*
- *Anxiety & Depression double the risk of a 1st heart attack and quadruples the risk for a repeat heart attack.*
- *Hostility raises risk of a heart attack by 29% and by 60% in people under 60 years old.*
- *Childhood trauma raises risk of a heart attack by 30 to 70%.*

WHY

- *Negative emotions affect the autonomic nervous systems which in turn affects all the organs.*
- *Depression, anger & hostility increase C-reactive protein…a blood marker for inflammation.*
- *Stress cardiomyopathy or "broken-heart syndrome caused from a major shock…people had 30 times the normal level of adrenaline, which is 4 to 5 times higher than people actually having a heart attack. This huge dose of hormone disrupts the way heart cells take up calcium, which affects the way the heart contracts.*



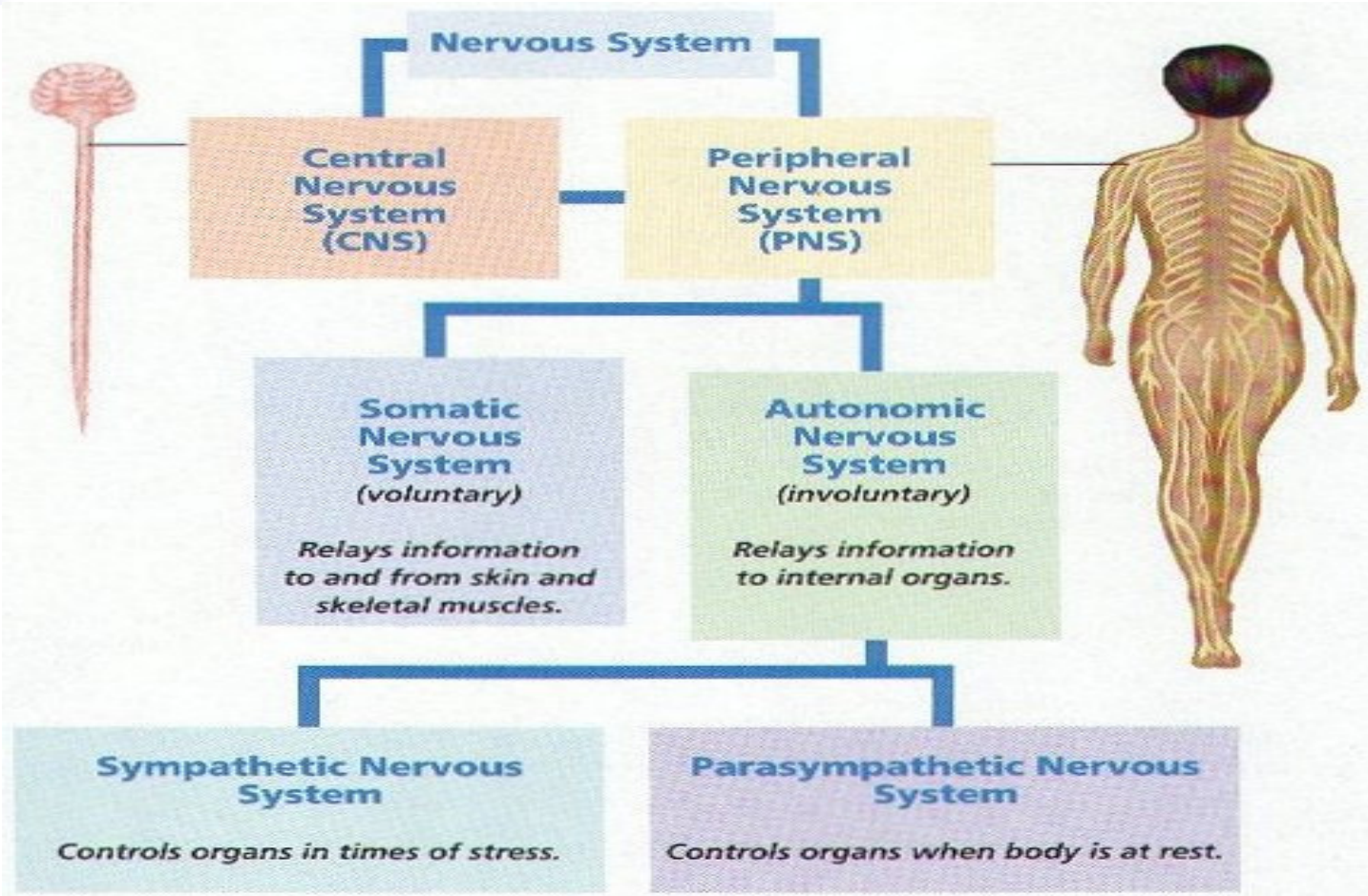


The Nervous System

The Nervous System is divided into :

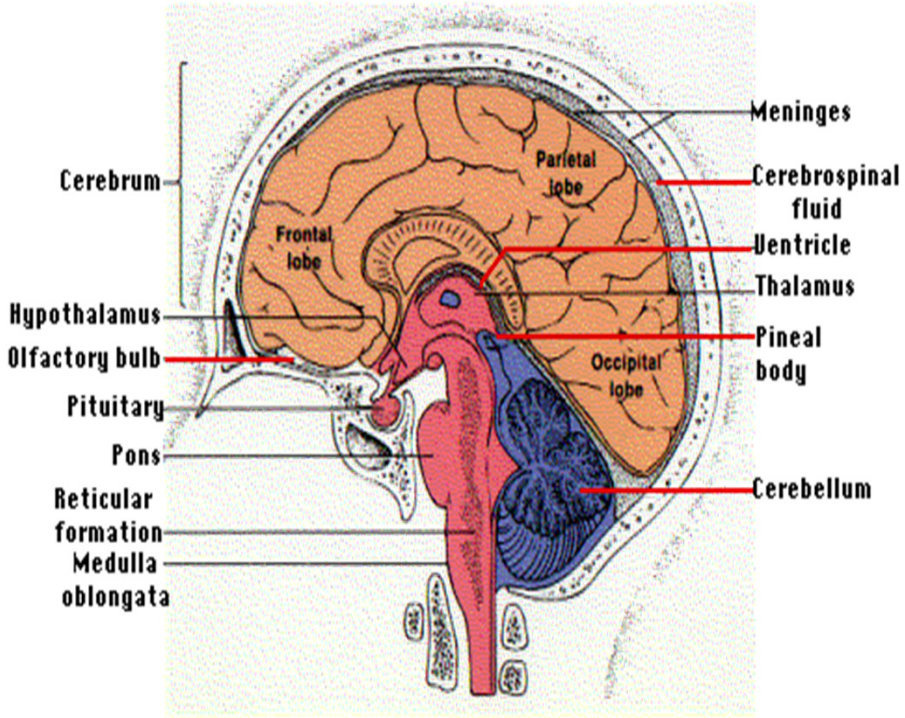
- The Central Nervous System (Brain and Spinal Cord)
- Peripheral Nervous System (divided into the somatic nervous system and the autonomic system)

The Nervous System



The Nervous System

The spinal cord acts as a communication link between the brain and the peripheral nervous system.



Central Nervous System

Control Center of the Body

- Relays Messages
- Processes Information
- Compares and Analyzes Information

Peripheral Nervous System

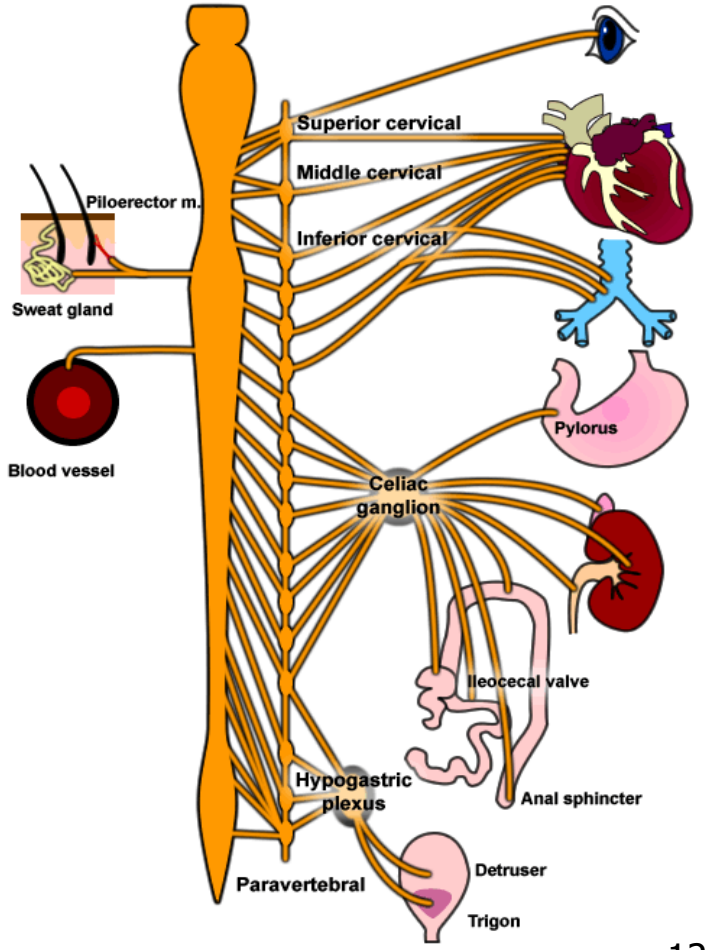
ALL OF THE NERVOUS SYSTEM OUTSIDE THE SPINAL CORD AND BRAIN IS KNOWN AS THE PERIPHERAL NERVOUS SYSTEM

- The peripheral nervous system consists of neurons NOT included in the brain and spinal cord.
- Some peripheral neurons, called afferent neurons, collect information from the body and transmit it **towards** the central nervous system.
- Other peripheral neurons, called efferent neurons, transmit information **away** from the central nervous system.

Autonomic Nervous System

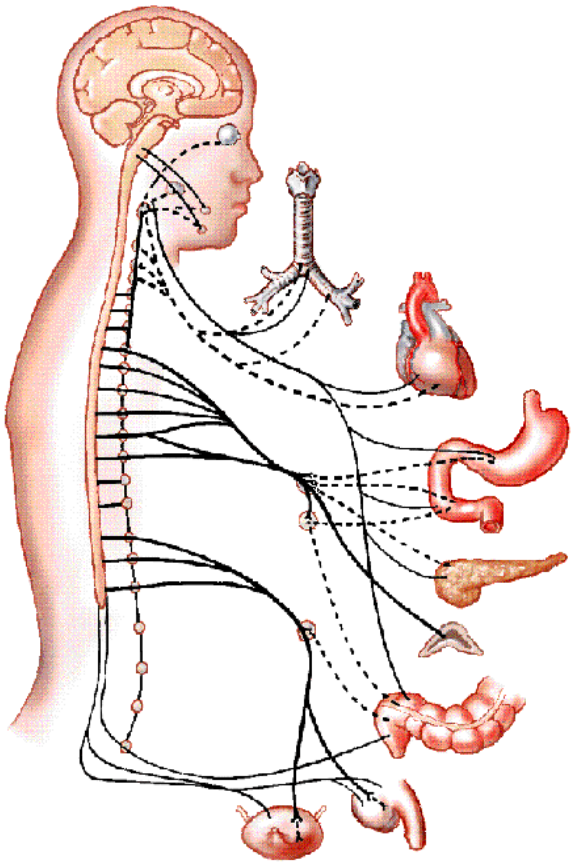
- Organs of our body such as the heart, stomach and intestines are regulated by the autonomic nervous system (ANS)

- ANS is divided into 3 parts : the sympathetic nervous system, the parasympathetic nervous system and the enteric (intestines) nervous system



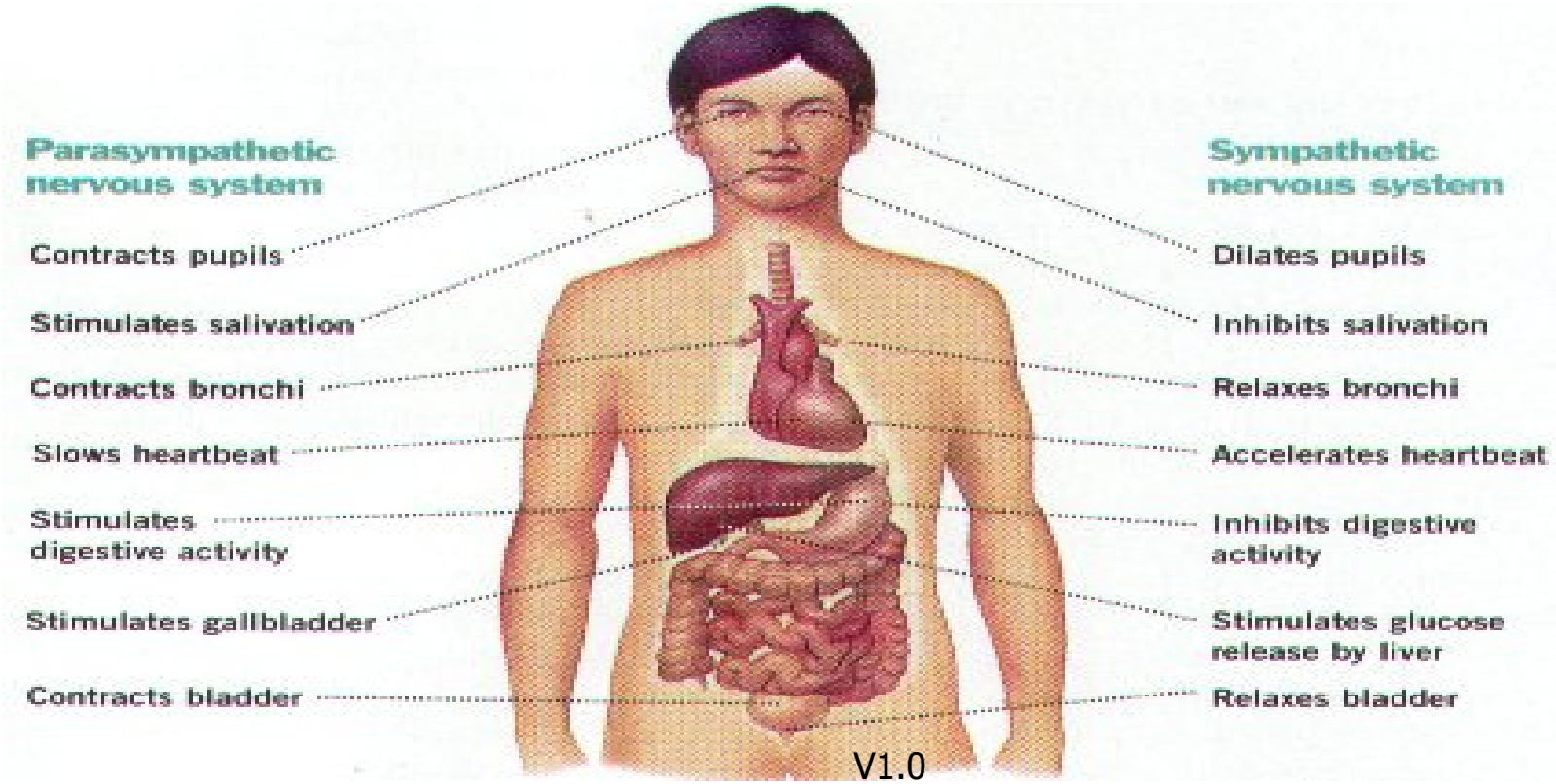
Autonomic Nervous System

- ANS consists of sensory neurons and motor neurons that run between the central nervous system and various internal organs (heart, lungs, viscera, glands)
- ANS regulates activities that are automatic, or involuntary
- The nerves of the ANS control functions of the body that are not under conscious control.
- ANS is concerned with striking a balance or maintaining homeostasis in the functioning of many organs of the body.

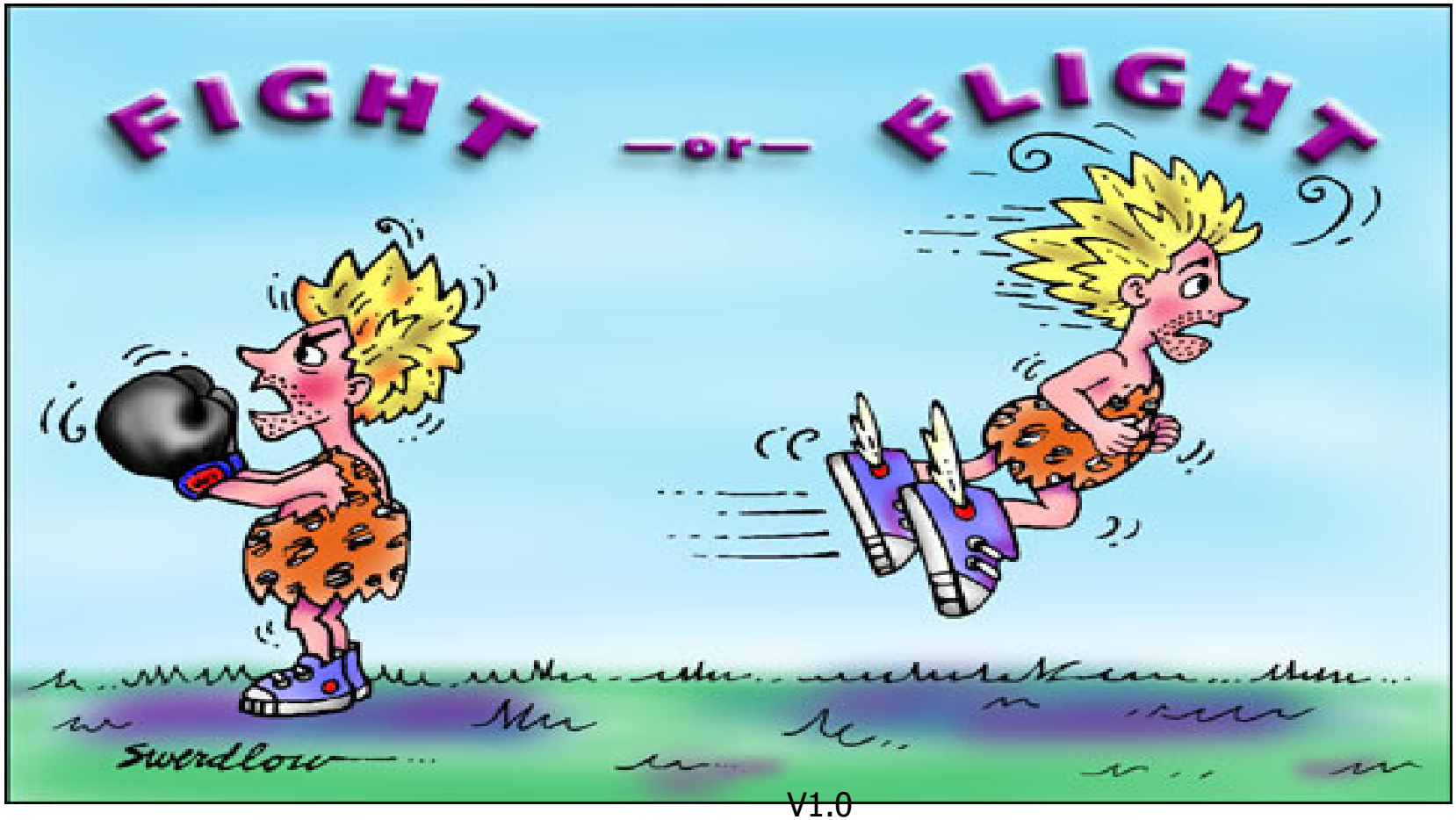


Autonomic Nervous System

Most organs controlled by the Autonomic Division are under control of both Sympathetic and Parasympathetic Neurons.



Sympathetic Nervous System



Sympathetic Nervous System

- Often referred to as your 'fight-or-flight' system, your sympathetic nervous system prepares your body for emergencies.
- Sympathetic nerves come from the thoracic and lumbar regions of the spinal cord
- It shunts your blood to your muscles and increases your blood pressure, heart rate and breathing rate, enabling you to cope with stressful situations.

Sympathetic Nervous System

- SNS normally functions to produce localized adjustments (such as sweating) and reflex adjustments of the CVS.
- Under conditions of stress, the entire SNS is activated, producing an immediate, widespread response that has been called the "flight or fight" response.
- Characterized by the release of large quantities of epinephrine from the adrenal gland, an increase in heart rate, an increase in cardiac output, skeletal muscle vasodilation, cutaneous (skin) and GI vasoconstriction, pupil dilation, and piloerection (hair stands on end)

SNS Stimulation

- Pupil dilation
- Saliva production reduced
- Mucus production reduced
- Heart rate and force of contraction increased
- Bronchial muscle relaxed
- Peristalsis reduced in stomach (movement)
- Motility of small and large intestines reduced (spontaneous movement)
- Increased conversion of glycogen to glucose in liver
- Decreased urine secretion
- Norepinephrine and epinephrine secreted (adrenals)
- Bladder wall relaxed, sphincter closed

Parasympathetic Nervous System

"The Brake"

- Main nerves of the PNS are the tenth cranial nerves – the vagus nerves, which originate in the medulla oblongata
- The PNS returns the body functions to normal after they have been altered by sympathetic stimulation – reverses changes when the danger is over.
- The vagus nerves help keep inflammation under control (acetylcholine from the motor neurons suppresses the release of inflammatory cytokines ie: TNF – tissue necrosis factor)

Parasympathetic Nervous System

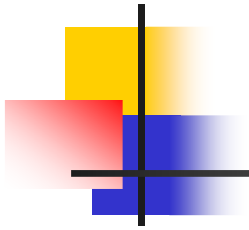
PNS stimulation causes:

- Slowing down of the heartbeat
- Lowering of the blood pressure
- Constriction of the pupils
- Increased blood flow to the skin and organs
- Facilitates digestion & absorption of nutrients

ANS Summary

ANS is a regulatory structure that helps people to adapt to changes in their environment. It adjusts or modifies some functions in response to stress and helps to regulate:

- Blood vessels' size and blood pressure
- Hearts electrical activity and ability to contract
- Diameter of bronchial tubes and thus air flow in the lungs
- Movement and work of the stomach, intestines and salivary glands.



"Autonomic Failure"

What Happens When There Is Autonomic Failure?

- Malfunction results from an imbalance between the SNS and PNS divisions.
- Aging is associated with several abnormalities in ANS function that can impair the ability to adapt to stress.

How Can We Assess The ANS?

SA3000P

Digital Pulsewave Analyzer

Cardio Wave Analyzer

Pulse Wave/HRV Analyzer

Two Programs

1. Plethysmograph waveforms to determine arterial elasticity
2. Heart Rate Variability – Autonomic Nervous System evaluation. Evaluates the level of balance between the branches of the ANS.

What Is Heart Rate Variability?

- Heart Rate Variability (HRV) – reflects the heart's ability to adapt to changing circumstances by detecting and quickly responding to unpredictable stimuli.
- Measures the beat-to-beat fluctuations in the rhythm of the heart and the intervals between successive complexes
- Sophisticated software enables us to measure imperceptible time differences between normal beats (N-N)
- The degree of variance is called Heart Rate Variability (HRV).

HRV History

- In the 18th century, Albrecht von Haller made the initial observation that the beat of a healthy heart is not absolutely regular.
- 1965 Hon & Lee noticed beat to beat interval changes are the first alteration before fetal distress occurs. (RR change precedes HR change)
- 1977 Wolf showed association of Heart Rate to sudden death post heart attack
- Late 1980's HRV confirmed strong predictor of mortality after a heart attack
- 2000 publications over the last decade found with MEDLINE search – key word "HRV"

HRV 5 Minute Analysis

- Recordings should be done at steady-state physiological conditions to produce comparable data
- Measurements should be done in either a lying facing upward or comfortably sitting relaxed position, limiting body movements, conversations and mental activities

HRV

- Heart rate variability (HRV) refers to the beat-to-beat alterations in heart rate.
- Under resting conditions, the ECG of healthy individuals exhibits periodic variation in RR intervals

HRV

- HRV is a noninvasive test of cardiovascular autonomic regulation.
- Specifically, HRV is a measurement of the interaction between sympathetic (i.e., "fight or flight" energy mobilization) and parasympathetic (i.e., the opposite of the sympathetic activity or "relaxation" response activity in autonomic functioning
- Reflection on how the body adapts to perform at maximum efficiency
- Measure of overall health and well being

HRV

- Low HRV has been shown in numerous longitudinal studies to be related to a higher mortality rate in both healthy and unhealthy subjects.
- It can be a predictor of all-cause mortality.

ANS Disorders Displayed In Low Variability

- Cardiac disease (Post MI, CHF,LVH)
- Diabetes
- Epilepsy
- Asthma
- Connective tissue disorder (Lupus)
- Rheumatoid Arthritis
- Nutritional deficiencies
- Genetics
- Long-term alcoholism
- Chronic renal disease
- Hypertension
- Depression
- Anxiety/panic attacks
- Chronic pain
- Constipation
- Silent inflammation

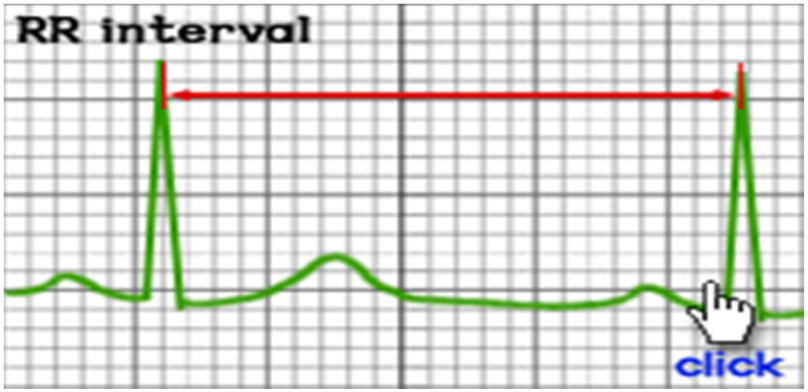
Time Domain / Frequency Domain

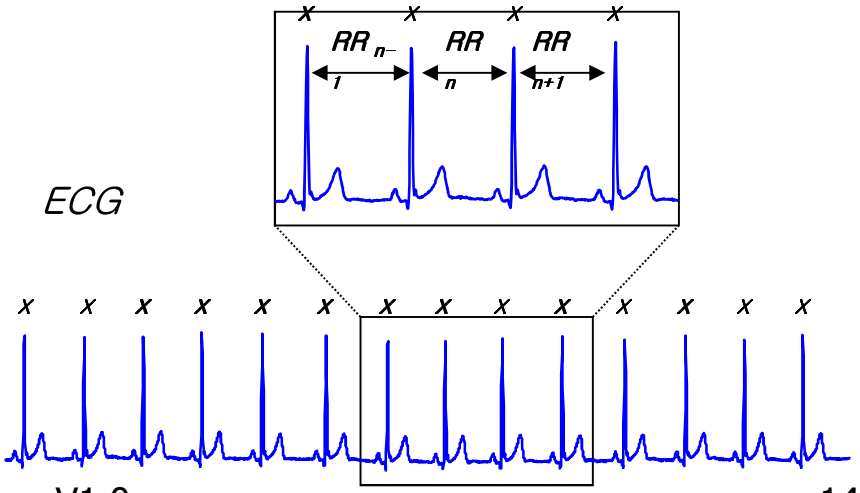
According to the Task Force of the European Society of Cardiology and North American Society of Pacing and Electrophysiology in 1996, there are two methods of analysis of HRV data:

1. Time Domain
2. Frequency Domain

Time Domain

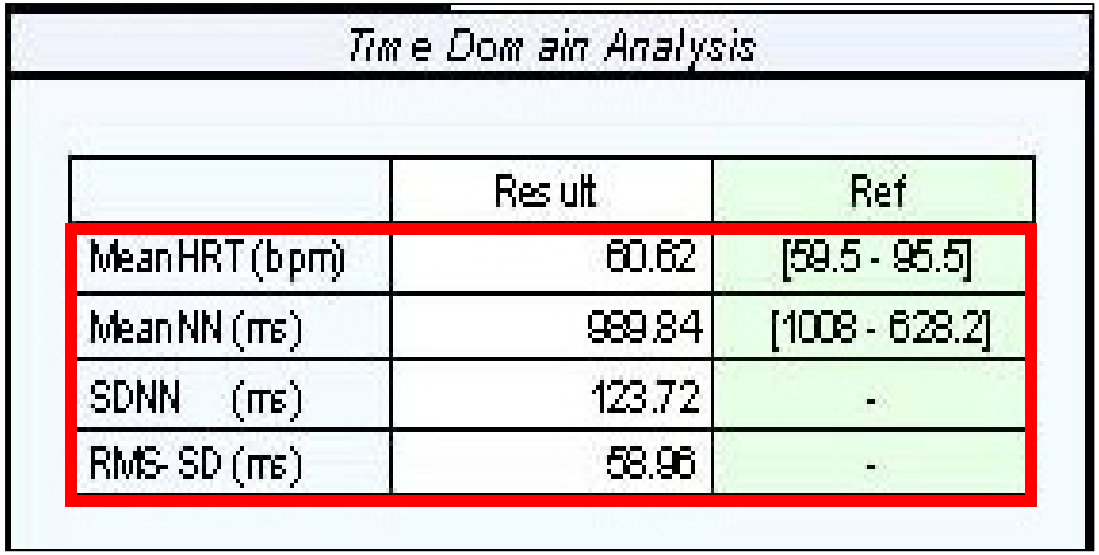
Normal to Normal (N-N) beats are measured - we capture the QRS complexes resulting from the sinus node depolarization.





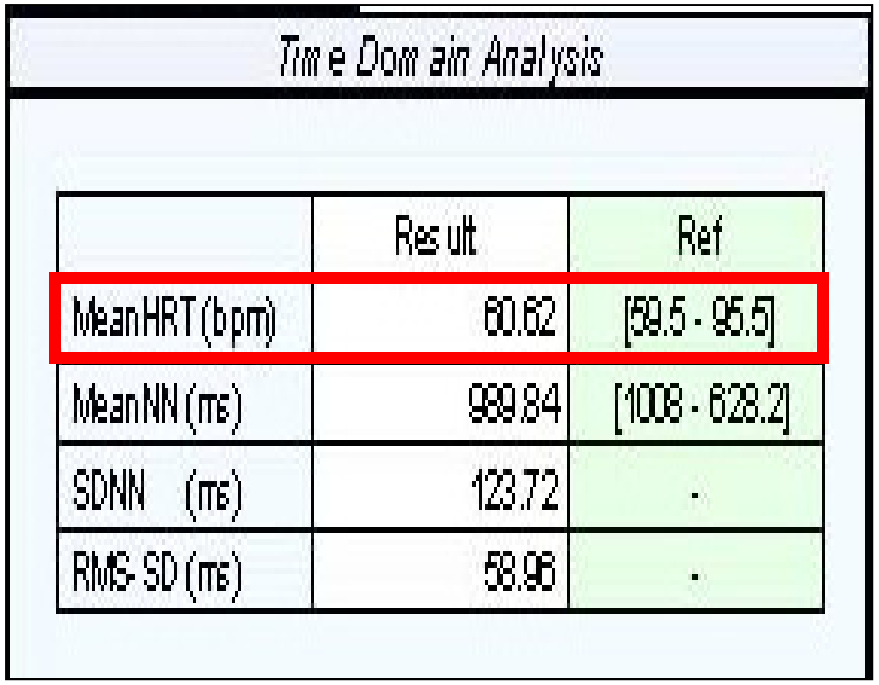
Time Domain

- Mean HRT (bpm)
- Mean NN (ms)
- SDNN (ms)
- RMS-SD (ms)



Mean Heart Rate

- Average Heart Rate over the 3-5 minute test period.
- Reference Range [59.5 – 95.5]



Time Domain Analysis

	Result	Ref
Mean HRT (bpm)	60.62	[59.5 - 95.5]
Mean NN (ms)	989.84	[1008 - 628.2]
SDNN (ms)	123.72	-
RMS-SD (ms)	58.96	-

Mean NN (ms)

- Measurement in milliseconds the average time between two regular heartbeats (Normal to Normal).
- 628.2ms – 1008 ms (normal range)
- <628.2 = seen in tachycardia (rapid HRT)
- >1008 = seen in bradycardia (slow HRT)

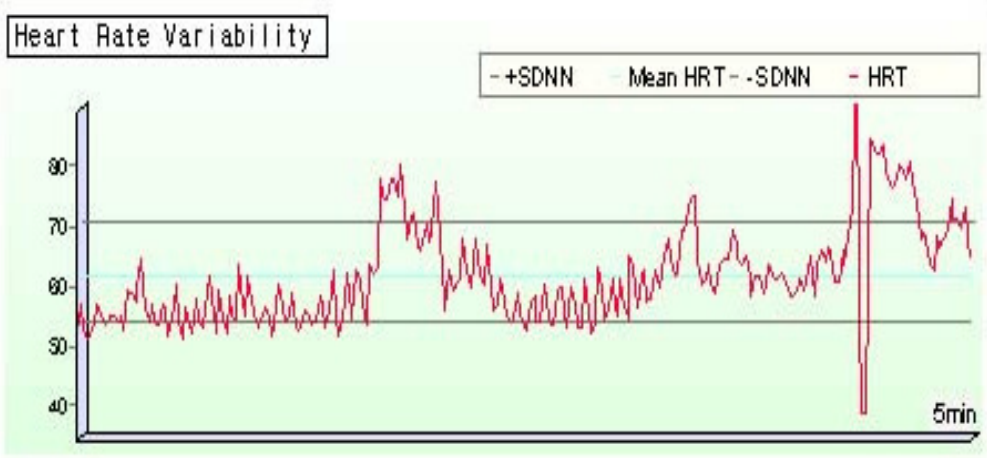
Time Domain Analysis

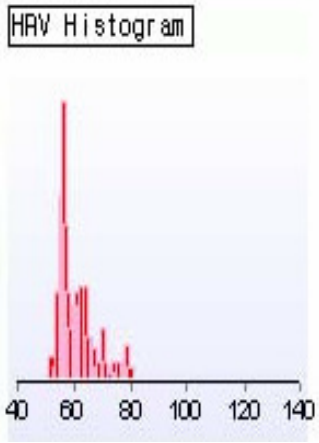
	Result	Ref
Mean HRT (bpm)	60.62	[59.5 - 95.5]
Mean NN (ms)	989.84	[1008 - 628.2]
SDNN (ms)	123.72	-
RMS-SD (ms)	58.96	-

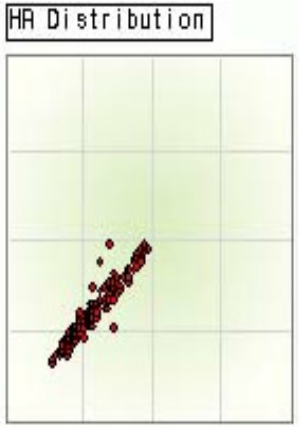
SDNN – Standard Deviation of Normal to Normal Beats

- Most common index of overall HRV
- Short-term time domain measures of HRV (3-5 min) are derived from the differences of successive RR intervals
- Highly correlated and considered to provide good estimates of ANS activity
- Reflects our ability to respond quickly, dynamically and effectively to a crisis

Report Parameters Relating to HRV







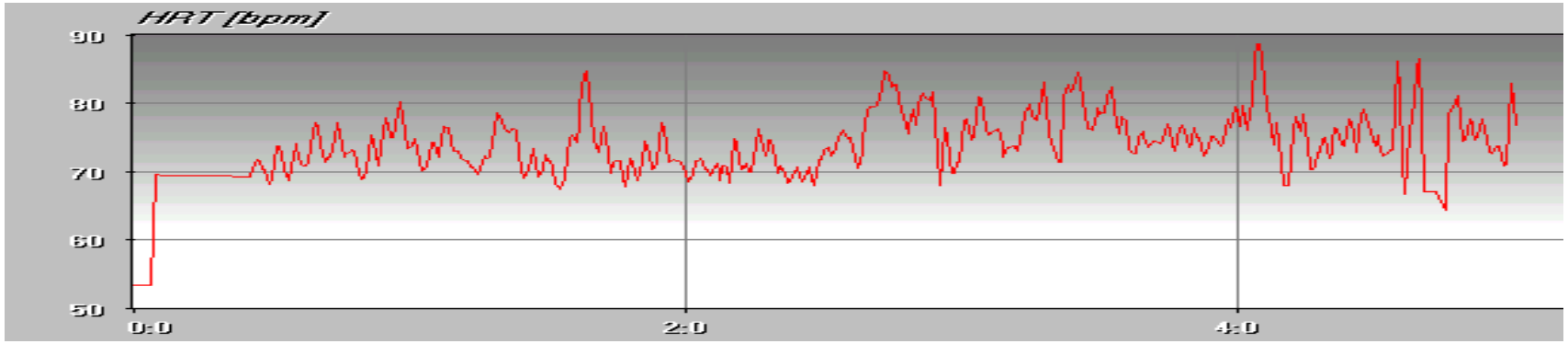
Time Domain Analysis

	Result	Ref
Mean HRT (bpm)	60.62	[59.5 - 95.5]
Mean NN (ms)	989.84	[1008 - 628.2]
SDNN (ms)	123.72	***<30 -- >100***
RMS-SD (ms)	58.96	-

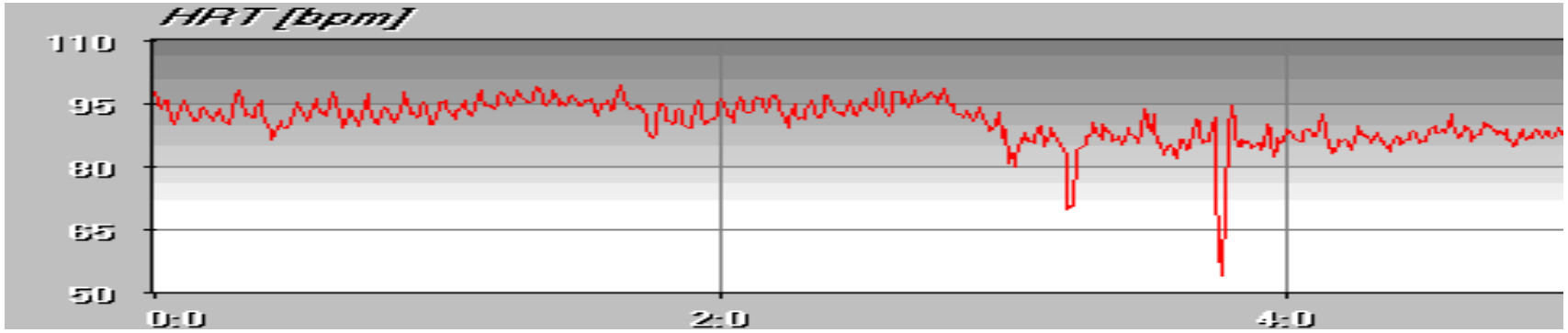
V1.0

HRV Changes

Normal HRV



Abnormal HRV



Standard Deviation Normal to Normal

(SDNN is poorly defined in literature)

General range:

- Very poor HRV <20
- Poor HRV 20 to 35
- Moderate HRV 35 to 50
- Optimal HRV >50

How To Improve SDNN

- Abstaining from smoking and practicing regular physical activity have been shown to raise the SDNN by 20%
- Decrease toxins (food and environment)
- Psychotherapy / stress reduction
- Supplementation with Omega 3 fatty acids (2g/day of fish oil) showed a significant increase in HRV
- Wine (1 glass/day for women and 2 glasses/day for men)

WINE???

A Stockholm research team studied the effect of alcohol consumption (over 1 year) on 102 women under the age of 75 who had survived a heart attack or surgery of blocked arteries:

- HRV was highest (good) in women who drank 5 or more grams of alcohol a day (equivalent to more than half a standard unit) and lowest (bad) in those who drank no alcohol at all.
- Beer and spirits had little impact on HRV

RMS-SD

- The square root of the mean squared differences of successive NN intervals
- This measure estimates high frequency variations in heart rate in short-term NN recordings that reflects an estimate of parasympathetic regulation of the heart.
- Mainly influenced by changes in PNS
- Reflects the electrical stability of heart
- Normal value 37$\pm$ 10 ms
- Higher risk of heart disease occurrence if RMS-SD and SDNN are both decreased

Frequency Domain Analysis (Spectral Analysis)

(Reflects levels of Sympathetic and Parasympathetic activity and their balance)

Power in 4 frequency bands analyzed:

- Total Power
- Very Low Frequency
- Low Frequency
- High Frequency

Frequency Domain Analysis

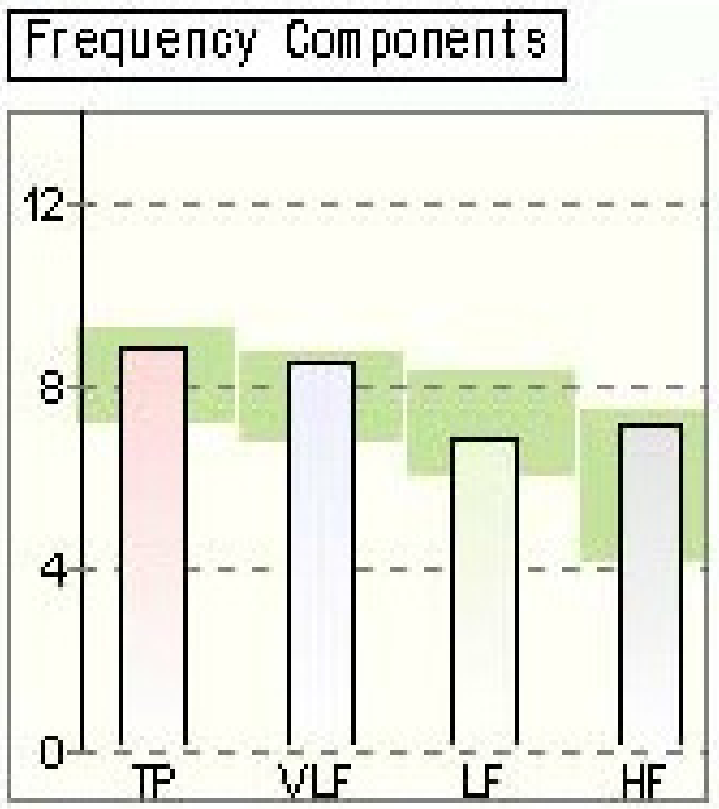
	Res(Power)	Res(log)	Ref
TP (ms2)	6871.00	8.84	[7.2-9.1]
VLF (ms2)	4678.00	8.45	[8.6-8.6]
LF (ms2)	929.35	6.83	[5.9-8.0]
HF (ms2)	1196.94	7.09	[3.8-7.1]
LF Norm (n.u)	42.34	.	.
HF Norm (n.u)	54.53	.	.
LF/HF Ratio	0.78	.	[0.6-2.4]

Spectral Analysis

- Frequency-domain measures pertain to HRV at certain frequency ranges associated with specific physiological processes.
- Numerous factors in health and disease have an impact on the amplitude and area of each peak (frequency range) on the HRV spectrum.
- Ample evidence that the frequency contributions to HRV are altered in illness states and that the degree of alteration correlates with illness severity.

Frequency Domain Analysis

- Also called “Power Spectral Density” PSD
- Produces low frequency, high frequency, very low frequency and total power (specific fuel tanks!)
- Magnitudes in the PSD in certain frequency ranges indicate the relative amount of activity in certain parts of the ANS and the level of stress of the subject.



PSD – Total Power (TP)

- Power Spectral Density (PSD) indicates relative power within each frequency domain derived from the waveform analysis of heart rate interval changes.
- Total Power = overall "vitality" in the system across all frequencies
- Total Power: a short-term estimate of the total power of spectral density in the range of frequencies representing the overall activity of the ANS (autonomic nervous system), however, sympathetic tone is considered as a primary contributor.
- Normal Range = 7.2 – 9.1 ms

TP = Total Power

Decreased TP

- Decrease of autonomic nerve activation
- Equates into decreased ability coping with internal/external stress

Increased TP

- Hyper-stimulated state

Frequency Domain Analysis

	Res(Power)	Res(log)	Ref
TP (ms2)	6871.00	8.84	[7.2-9.1]
VLF (ms2)	4676.00	8.45	[8.6-8.8]
LF (ms2)	929.35	6.83	[5.9-8.0]
HF (ms2)	1196.94	7.09	[3.8-7.1]
LF Norm (n.u)	42.34	.	.
HF Norm (n.u)	54.53	.	.
LF/HF Ratio	0.78	.	[0.6-2.4]

VLF = Very Low Frequency

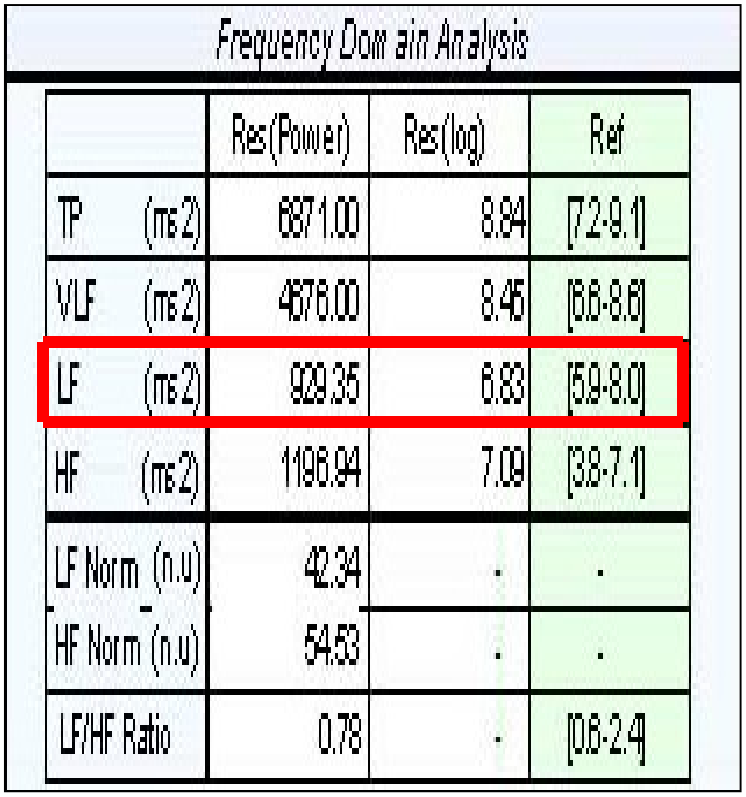
- **This measure is not well defined in terms of physiological mechanisms.**
- **With 24 hour recordings, it is considered representing sympathetic tone.**
- **There are some findings in shorter recordings VLF has fair representation of various negative emotions, worries, etc.**
- **Normal range is 6.6 to 8.6**

Frequency Domain Analysis

	Res(Power)	Res(log)	Ref
TP (ms2)	6871.00	8.84	[7.2-9.1]
VLF (ms2)	4678.00	8.45	[6.6-8.6]
LF (ms2)	929.35	6.83	[5.9-8.0]
HF (ms2)	1196.94	7.09	[3.8-7.1]
LF Norm (n.u)	42.34	.	.
HF Norm (n.u)	54.53	.	.
LF/HF Ratio	0.78	.	[0.6-2.4]

LF = Low Frequency

- This frequency band can reflect both sympathetic and parasympathetic activity.
- LF decrease = produces symptoms of internal energy loss, fatigue, lethargy. Generally a history of sleep deprivation. (adrenal fatigue)
- Normal range is 5.9 to 8.0



Frequency Domain Analysis

	Res(Power)	Res(log)	Ref
TP (ms2)	6871.00	8.84	[7.2-9.1]
VLF (ms2)	4676.00	8.45	[8.0-8.8]
LF (ms2)	929.35	6.83	[5.9-8.0]
HF (ms2)	1198.84	7.09	[3.8-7.1]
LF Norm (n.u)	42.34	.	.
HF Norm (n.u)	54.63	.	.
LF/HF Ratio	0.78	.	[0.6-2.4]

HF = High Frequency

- **This frequency band reflects parasympathetic (vagal or nerve) tone and fluctuations caused by respiration known as respiratory sinus arrhythmia.**
- **Parasympathetic tone helps to prevent ventricular arrhythmias by maintaining the electrical stability of the heart.**
- **Decreased HF = result of chronic stress, cardiopulmonary aging, heart disease.**
- **Normal range is 3.8 to 7.1**

Frequency Domain Analysis

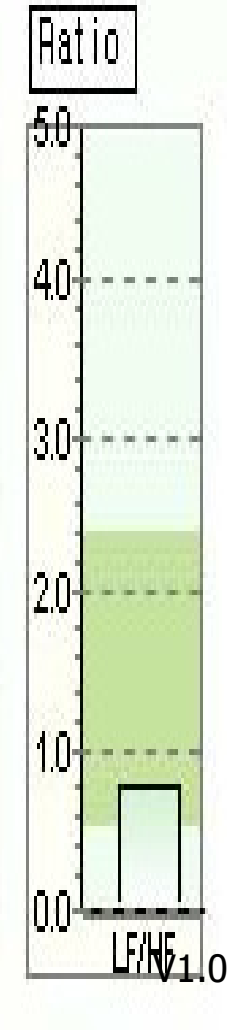
	Res(Power)	Res(log)	Ref
TP (ms2)	6871.00	8.84	[7.2-9.1]
VLF (ms2)	4676.00	8.45	[8.6-8.6]
LF (ms2)	929.35	6.83	[5.9-8.0]
HF (ms2)	1196.84	7.09	[3.8-7.1]
LF Norm (n.u)	42.34	.	.
HF Norm (n.u)	54.53	.	.
LF/HF Ratio	0.78	.	[0.6-2.4]

Frequency Components
(Signs and Symptoms)

TP decrease	VLF decrease	LF decrease	HF decrease
▪ Decrease of autonomic nerve activation ▪ Decreased coping ability with internal/external stress	▪ Temperature control ▪ Blood pressure activity	▪ Internal energy loss ▪ Fatigue ▪ Lack of sleep ▪ Lethargy	▪ Chronic stress ▪ Cardiopulmonary aging ▪ Anxiety, heart diseases ▪ Decreased electrical stability of heart

LF/HF Ratio

- **Ratio between the power of Low Frequency (LF) and High Frequency (HF) bands**
- **Normal Range is 0.6 to 2.4**
- **Indicates overall balance between sympathetic and parasympathetic system.**
- **Value greater than 2.4 = Sympathetic Dominance**
- **Value less than 0.6 = Domination of the Parasympathetic system.**



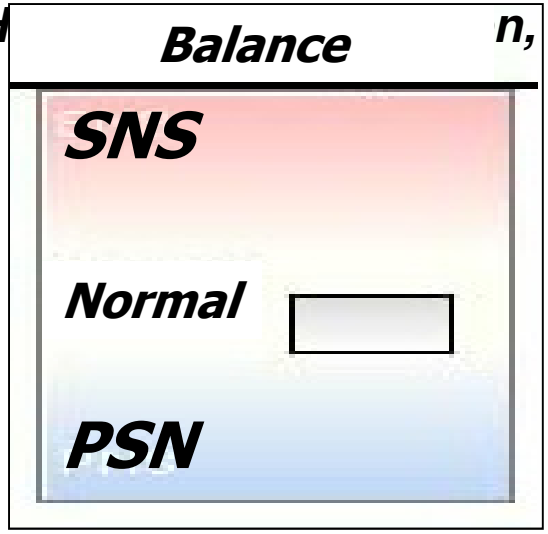
Frequency Domain Analysis

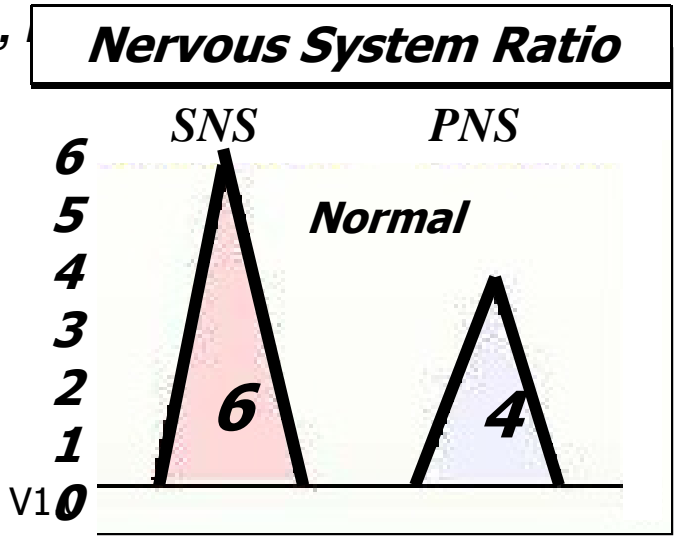
	Res(Power)	Res(log)	Ref
TP (ms2)	6871.00	8.84	[7.2-9.1]
VLF (ms2)	4576.00	8.45	[8.6-8.8]
LF (ms2)	929.35	6.83	[5.9-8.0]
HF (ms2)	1198.84	7.09	[3.8-7.1]
LF Norm (n.u)	42.34	.	.
HF Norm (n.u)	54.53	.	.
LF/HF Ratio	0.78	.	[0.6-2.4]

SNS/PNS Balance

***SNS** (sympathetic nervous system) & **PNS** (parasympathetic) Balance*

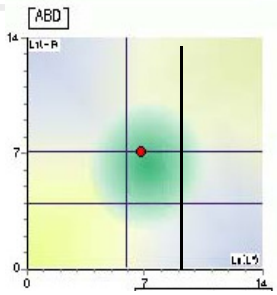
- *SNS and PNS ratio is normal at around 6:4*
- *Higher SNS: nervous, anxiety, agitation, excitement, increasing blood pressure, headache, etc.*
- *H n, sluggishness,*

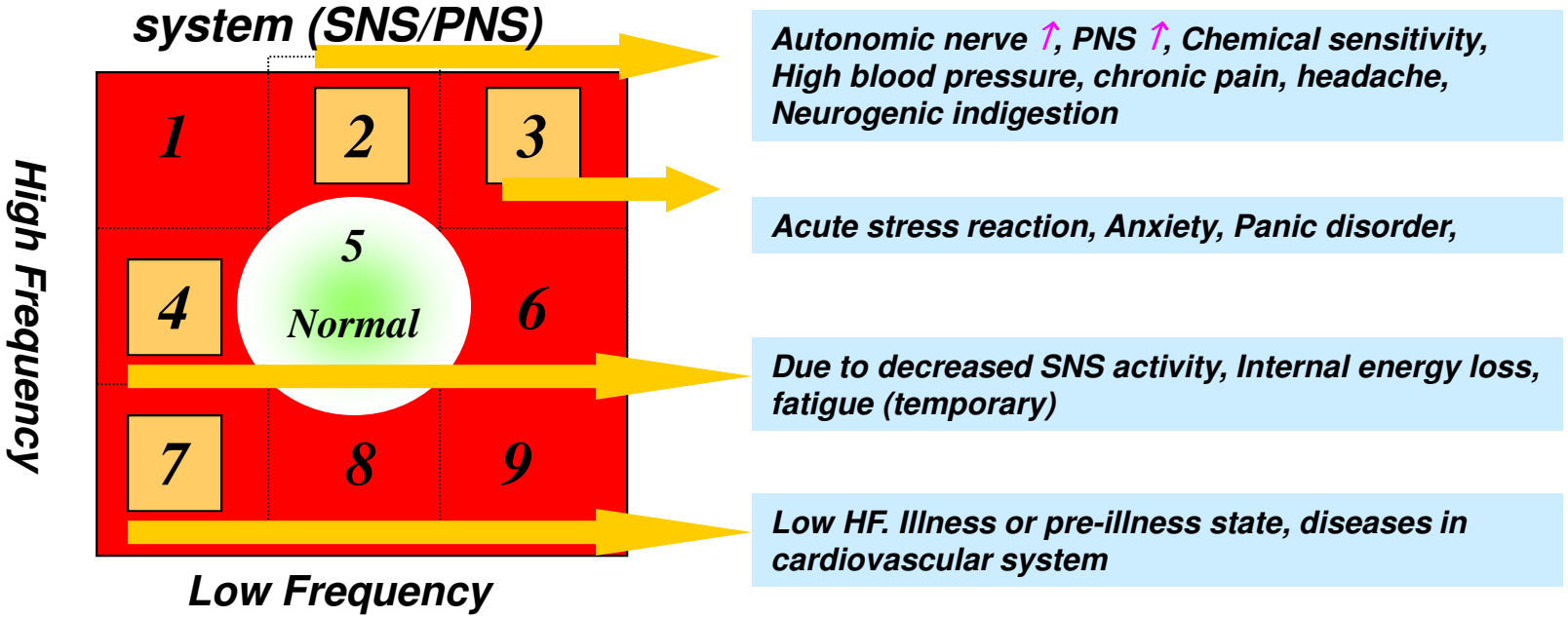




ABD = Autonomic Balance Diagram

- ***Most important part in HRV evaluation***
- ***Indicating active status of autonomic nervous***





※ *Numbers 1,6,8,9 are not applicable*

Reminders

- One of the important issues when measuring HRV is the absence of abnormal heartbeat used in interval detection.
- Only heartbeats originated in the sino-atrial node can be processed to obtain HRV data.
- Ectopic beats whether premature ventricular contractions (PVCs) or extrasystolic beats or various movement artifacts will give you a false reading.
- Remember, HRV measures intervals between N-N (normal to normal beats)

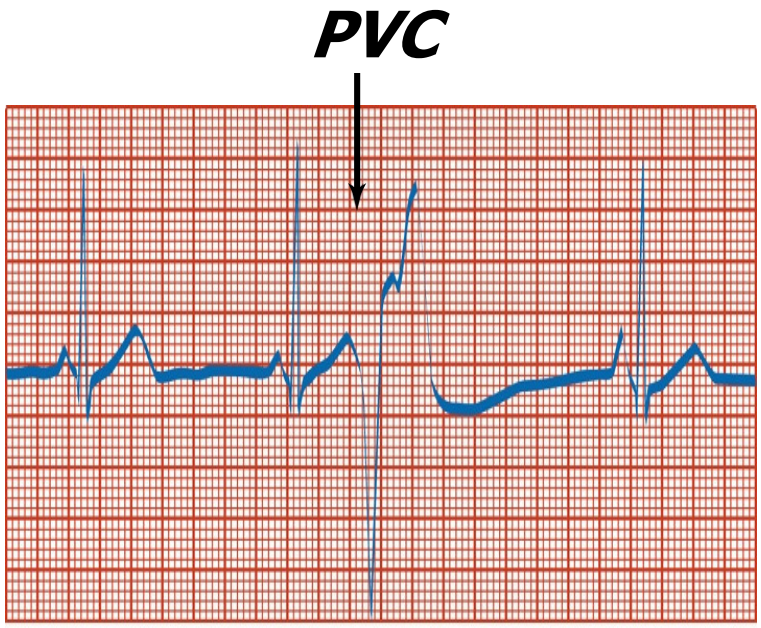


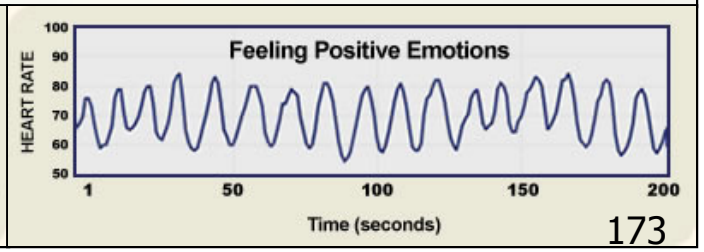
Figure 17-36 R-on-T premature ventricular contraction. (From Huff J: ECG Workout [4th Ed], p 195. Philadelphia, Lippincott Williams & Wilkins, 2002.)

HRV Balancing--Minerals

	Sympathetic	Parasympathetic
Magnesium	Blocking Action	
Potassium		Stimulating Action
Sodium	Stimulating Action	
Calcium		Blocking Action

HRV Balancing--emwave

It reduces stress by training you to create more "coherence." Scientists use the term coherence to describe a highly efficient physiological state in which the nervous, cardiovascular, hormonal and immune systems are working efficiently and harmoniously. Coherence is a state very similar to what athletes experience when they are in what is called "the zone."



Herophilus (Greek Physician 320 BC)

"When health is absent, wisdom cannot reveal itself, art cannot manifest, strength cannot fight, wealth becomes useless, and intelligence cannot be applied."

NAME: _____ ***DATE:*** _____

Heart Rate Variability Quiz

1. What are the two parts of the nervous system?

- ***a. Somatic and autonomic***
- ***b. Sympathetic and Parasympathetic***
- ***c. Brain and Spinal Chord***
- ***d. Central and Peripheral***

2. What acts as the communication link between the brain and the peripheral nervous system?

- ***a. The medulla oblongata***
- ***b. The aorta artery***
- ***c. The spinal chord***
- ***d. The endothelium***

3. Which is not part of the autonomic nervous system?

- ***a. Somatic***
- ***b. Enteric***
- ***c. Parasympathetic***
- ***d. Sympathetic***

4. Which is not a true statement about the autonomic nervous system (ANS)?

- ***a. The ANS is concerned with maintaining homeostatis.***
- ***b. The nerves of the ANS control functions of the body that are under control of the conscious mind.***
- ***c. The ANS regulates activities that are involuntary.***
- ***d. The ANS connects the central nervous system and various internal organs.***

5. TRUE or FALSE – The parasympathetic nervous system is the flight or flight and the sympathetic nervous system is the brakes.

HRV Quiz Cont.

6. Which is NOT a stimulation of the sympathetic nervous system?
   a. Increase in mucus production
   b. Pupil dilation
   c. Increase in heart rate
   d. Increase in sweat production

7. Which is NOT a stimulation of the parasympathetic nervous system?
   a. Decrease of blood pressure
   b. Decrease of heart rate
   c. Constriction of pupils
   d. Decrease in blood flow to the skin

8. What is best description of heart rate variability?
   a. The measurement of the variance of neurons communicating with the autonomic nervous system.
   b. The measurement of imperceptible time differences between abnormal beats of the heart.
   c. The reflection of the heart's ability to adapt to changing circumstances by detecting and quickly responding to unpredictable stimuli.
   d. The measurement of how well the brain is communicating with the heart through the somatic nervous system.

HRV Quiz Cont.

9. The history of the heart rate variability dates back to the 18th century, but in the last 10 years there have been how many published studies?
   a. 500
   b. 1000
   c. 2000
   d. 3000

10. TRUE or FALSE – Heart rate variability is related to high mortality in only unhealthy subjects.

11. What is standard deviation of normal-to-normal beats (SDNN)?
   a. The most common index for HRV.
   b. Highly correlated but considered to provide poor estimates on ANS activity.
   c. Reflects our ability to relax during a time or crisis.
   d. The short time domain measures of HRV and is derived from successive N-N intervals.

12. TRUE or FALSE – There is a higher risk of heart disease occurrence if RM-SSD and SDNN are both decreased.

13. Frequency domain analysis measures how many frequencies?
   a. 4
   b. 6
   c. 8
   d. 10

HRV Quiz Cont.

14. What does PSD stand for?
    a. Polar Special Domain
    b. Power Spectral Density
    c. Positive Social Display
    d. Politically Standard Demographic

15. What does Total Power (TP) refer to?
    a. The overall strength of the autonomic nervous system.
    b. The overall vitality in the nervous system across all frequencies.
    c. The power produced in the mitochondria.
    d. How much horsepower is produced with every beat of the heart.

MATCH THE RANGES OF THE FREQUENCIES

16. Total Power (TP)	3.8 – 7.1
17. Very Low Frequency (VLF)	5.9 – 8.0
18. Low Frequency (LF)	0.6 – 2.4
19. High Frequency (HF)	7.2 – 9.1
20. LF / HF Ratio	6.6 – 8.6

HRV Quiz Cont.

MATCH THE SYMPTOMS TO THE FREQUENCY

21. Total Power (TP)	Lack of Sleep
22. Very Low Frequency (VLF)	Decreased Electrical Stability
23. Low Frequency (LF)	Decrease in Temperature Control
24. High Frequency (HF)	Decreased Coping Ability

25. What ratio shows the proper balance of the sympathetic to parasympathetic systems?
    a. 2:1
    b. 6:3
    c. 3:5
    d. 6:4

26. What is the most important part in HRV evaluation?
    a. Whether the client stays awake for the test.
    b. Low frequency to high frequency ratio.
    c. Autonomic balance diagram.
    d. Sympathetic to parasympathetic ratio.

27. What five (5) quadrants are used in the autonomic balance diagram?
    a. 2, 3, 4, 5, 7
    b. 1, 3, 6, 8, 9
    c. 1, 3, 5, 7, 9
    d. 2, 4, 6, 8, 9

HRV Quiz Cont.

28. Which quadrant relates to a normal reading of the autonomic nervous system?
    a. 2
    b. 3
    c. 4
    d. 5

29. Which quadrant can show a pre-illness of the cardiovascular system?
    a. 2
    b. 3
    c. 6
    d. 7

30. How long is the screening for heart rate variability?
    a. 1 minute
    b. 2 minutes
    c. 3-5 minutes
    d. 10 minutes