VIVE LA FRANCE:

COMPARING HEART HEALTH BETWEEN THE U.S. AND FRANCE

BY:

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Abstract

The goal of this study is to investigate the components and differences of the modifiable risk factors for Coronary Artery Disease (CAD) between individuals diagnosed in both the United States and France. The amount of deaths associated with CAD in the United States greatly outweighs the amount of CAD related deaths in France. More than 18% of all deaths in the U.S. are due to CAD, while in France, that statistic is reduced to just 9%. Out of 172 countries, the United States ranks 107th for highest percentage of deaths from CAD, while France ranks 171st. Risk factors that were analyzed and compared include dyslipidemia, hypertension, cigarette smoking, diabetes, and obesity. The majority of these risk factors are comparably similar between both countries with the exception of dyslipidemia and cigarette smoking being slightly higher in France. However, there is a large difference in the prevalence of obesity. The United States possesses a 35% rate of obesity while France averages just 14.5%. While it remains unclear as to why France has a much lower rate of CAD than the US, it is reasonable to speculate that twice the amount of obesity will also double the amount of CAD.

L’abstrait

Le but de cette étude étudie les composantes et les différences entre les facteurs de risque modifiables pour la maladie coronarienne (CAD) entre les individus diagnostiqués aux États-Unis et en France. La quantité des morts associés à CAD aux États-Unis est beaucoup plus que la quantité de CAD morts associés en France. Plus de 18% de tous les morts aux États-Unis sont dus à CAD, mais en France, cette statistique est réduite à seulement 9%. Sur de 172 pays, les États-Unis sont 107e pour le plus haut pourcentage des morts de CAD, mais France est seulement 171e. Les facteurs de risque qui ont analysés et comparés comprennent la dyslipidémie, l'hypertension, le tabagisme, le diabète et l'obésité. La majorité de ces facteurs de risque sont comparables similaires entre les deux pays, à l'exception de la dyslipidémie et le tabagisme qui sont légèrement plus élevé en France. Cependant, il y a une grande différence dans la prévalence de l'obésité. Les États-Unis possède un taux de 35% d'obésité, mais France a seulement un taux de 14,5%. Bien qu'il reste difficile de comprendre pourquoi France a un taux beaucoup plus moins de CAD que les États-Unis, il est raisonnable de supposer que deux fois la quantité de l'obésité sera doubler la quantité de CAD aussi.

Introduction to the Cardiovascular System

The word "cardiovascular" is a combination of two terms: *cardio-* = heart, and *–vascular* = blood or blood vessels. The heart, blood vessels, and blood encompass the three primary components of the cardiovascular system, which permits the pumping, circulation, and delivery of blood and nutrients to each and every cell within the body. Improper function of the cardiovascular system's basic components would likely decline blood and nutrient delivery, which can affect every other organ system of the body as well, such as bone health, digestive organs, nervous system, and even constituents of the cardiovascular system itself.

Introduction to the Heart

The heart is responsible for the continuous pumping and circulation of blood throughout the body. From birth until death, the heart never stops beating with the exception of the fraction of a second it takes to rest in between beats. An average human accumulates about 100,000 heartbeats in one day, which amounts to approximately 3 billion beats in an average lifespan. At a given moment in time, there are approximately 5 liters of blood circulating through the body, which means the heart pumps about 14,000 liters of blood per day. To preserve cellular function throughout, the heart must continue to pump blood through vessels that lead to each and every cell within the body.

I. Basic Anatomy of the Heart

The heart sits in the midline of the thoracic cavity between both lungs and just above the diaphragm. It lies posterior to the sternum and anterior to the vertical column as is shown in Figure 1.

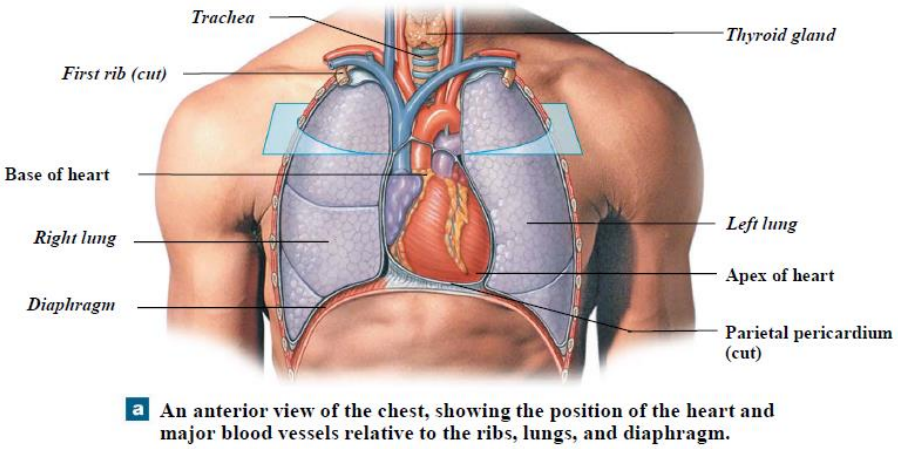


Figure 1. Location of the Heart in the Thoracic Cavity

The heart is approximately the same size as a clenched fist, and though it is an organ composed entirely of muscle, it contains four hollow cavities on the interior used for pumping blood. These cavities are referred to as the four chambers of the heart and are comprised of two atria and two ventricles, which can be seen in Figure 2. The atria are the superior chambers that receive blood coming into the heart. The two ventricles are located just below the atria and are responsible for pumping blood out of the heart. Furthermore, the heart is separated into a right and left half, which contains one atrium and one ventricle each. The two halves are separated by an area of cardiac muscle referred to as the interventricular septum.

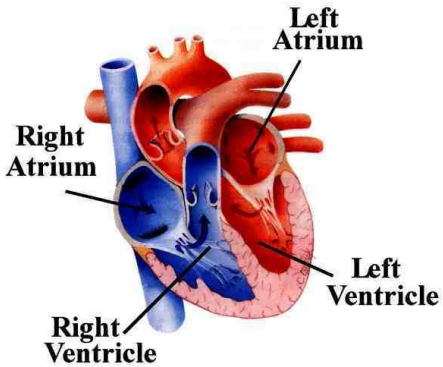


Figure 2. Four Chambers of the Heart

II. The Heart as a Muscle

There are three layers of tissue that make up the heart wall: the pericardium, myocardium, and the endocardium (Figure 3). The external layer, also called the pericardium is composed of two tissue layers: the inner layer being the epicardium and the outer layer is called the visceral layer of the pericardium. The myocardium is the thickest layer of the heart wall and it constitutes the cardiac muscle layer of the heart. It is responsible for the contraction of the heart that permits blood to be forcibly pumped through the chambers. The cardiac muscle cells of the myocardium act as one functional syncytia. They develop very close together and are joined adjacently by structures called intercalated discs. These structures allow communication between the tightly packed cardiac cells and they also prevent separation between the cells during contraction. Therefore, the muscle fibers of the atria or ventricles contract together at once. The inner most layer is a thin lining of endothelium called the endocardium. Not only does this endothelium line the inner heart wall, it also lines the entire circulatory system.

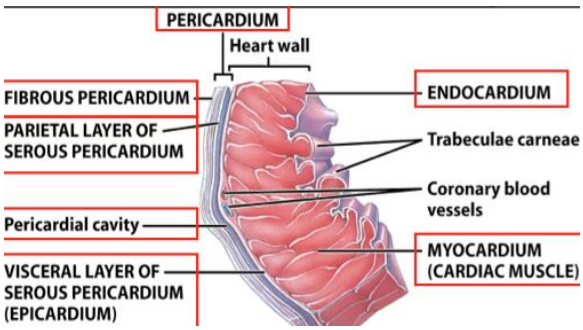


Figure 3. Layers of the Heart Wall

III. Internal Anatomy of the Heart

Within the four chambers of the heart, the heart also possesses four one-way valves that only open from behind when enough pressure builds up from the contraction of cardiac muscle

to move blood forward. These valves ensure that blood is continuously pushed forward and they prevent any blood from moving in the opposite direction. There are two atrioventricular valves that separate each atrium from a ventricle. As seen in Figure 4, the left atrioventricular valve is referred to as the mitral valve (or the bicuspid valve), and it is responsible for preventing the backflow of blood from the left ventricle into the left atrium. The right atrioventricular valve, also known as the tricuspid valve, prevents blood from flowing back from the right ventricle into the right atrium. Additionally, there are two semilunar valves that open when enough pressure builds up in the ventricles to allow blood into either the pulmonary trunk or the aorta. Thus, the pulmonary valve separates blood flow between the right ventricle and the pulmonary trunk, while the aortic valve serves as the barrier between the left ventricle and the aorta.

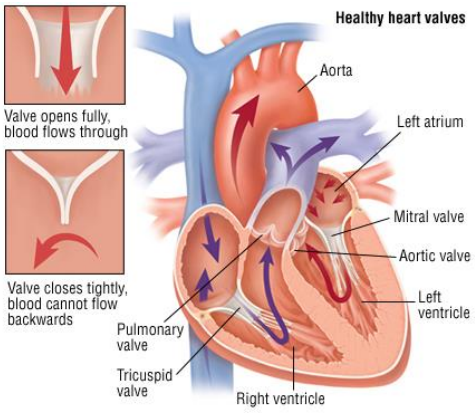


Figure 4. Heart Valves

IV. Heart Valves and the Circuit of Blood Flow through the Heart

The heart operates as a dual-pump. The right and left sides of the heart function separately as two different pumps. In other words, the right atrium supplies blood to the right ventricle,

while the left atrium supplies blood to the left ventricle. Both of the atria contract at the same time, allowing the ventricles to fill up simultaneously, as can be seen in Figure 5.

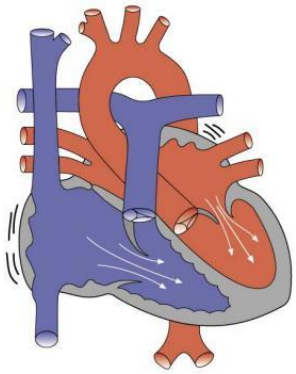


Figure 5. Atrial Contraction

Likewise, the ventricles contract together as well, pushing blood out of the lower chambers of the heart also at a simultaneous rate.

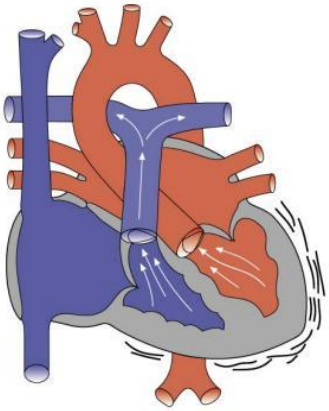


Figure 6. Ventricular Contraction

The blood flow from one side has a different destination from the other side, meaning the blood being pumped out of the right ventricle is directed towards the lungs for oxygenation in a process called pulmonary circulation, while blood being pumped out of the left ventricle is conducted to the rest of the body for systemic circulation. These processes occur

simultaneously as a functional syncytia, similar to the individual cardiac cells of the myocardium. Each heartbeat is the result of a contraction and relaxation. Therefore, it is the movement of blood into the two separate circuits.

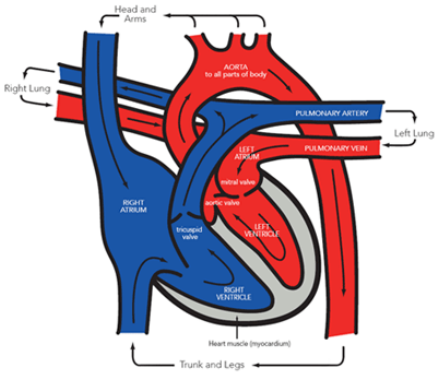


Figure 7. Path of Blood Through the Heart

The output of one circuit leads to the input of another. For example, after oxygenated blood has been delivered to the rest of the body in systemic circulation, the blood becomes deoxygenated and is returned to the heart in the right atrium through either the Superior or Inferior Vena Cava. After atrial contraction, deoxygenated blood moves through the tricuspid valve from the right atrium into the right ventricle. After a certain pressure gradient has been met in the ventricle, blood will push through the pulmonary valve and enter pulmonary circulation, where it will travel to the lungs via the pulmonary arteries and receive oxygen from the inhalation of air. Oxygenated blood will then travel back to the heart and enter the left atrium from the pulmonary veins. This is the input of systemic circulation resulting from the output of pulmonary circulation. The blood then moves through the mitral valve and fills the left ventricle until the pressure gradient pushes it out through the aortic valve and into the aorta, where blood can then diffuse throughout the body and deliver the oxygen and nutrients

that each cell needs. The output of this systemic circulation then returns back to the heart once again to become the input for pulmonary circulation.

Introduction to the Blood

Blood is a liquid connective tissue that functions as an oxygen and nutrient supplier to every single cell in the human body. It's a transporting reservoir for both nutrients and wastes and it's composed of both cellular and non-cellular components. On average, there is about 5-5.5 liters of blood in the human body at a given time. The blood is recycled through the heart and cardiovascular system repeatedly for re-oxygenation and transportation of different substances. As for the functions of blood, there are primarily three: transportation, regulation, and protection. Each of these functions involves different components of the blood, which can be either cellular or non-cellular factors.

I. Cellular Components of Blood: Red Blood Cells

About forty-five percent of blood is comprised of cellular components, which contains three principle elements: red blood cells, white blood cells, and platelets.

Red blood cells, or erythrocytes, make up ninety-nine percent of these cellular components. There are approximately five billion erythrocytes in one milliliter of blood. These red blood cells function as oxygen-carrying cells throughout the vasculature of the body in order to deliver oxygen to the tissues and retrieve carbon dioxide back to the lungs.

The red blood cell anatomy is unique in comparison to other cells of the body because they don't contain a nucleus or any organelles that would normally operate a eukaryotic cell. In fact, most of the erythrocyte structure is taken up by oxygen-carrying proteins called hemoglobin.

These proteins characterize the specialty of red blood cells, which allows them to transport oxygen throughout the body. The biconcave disc shape of red blood cells provides a greater surface area for the diffusion of oxygen into and out of the cell. Within each RBC, there are about 280 million hemoglobin proteins. Each of these molecules possesses four heme groups, which are non-protein structures that contain iron ions used to bind oxygen. Thus, each hemoglobin can bind four oxygen molecules (Figure 8).

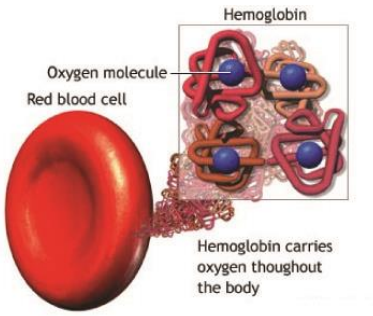


Figure 8. Red Blood Cell with Hemoglobin

The production of red blood cells is called erythropoiesis and is based primarily on the need in oxygen delivery. The production starts in the red bone marrow in a precursor cell called a proerythroblast. After numerous divisions the development of reticulocytes begins to take place and cells with hemoglobin molecules start to form. The maturation of red blood cells is complete once the organelles are no longer present and the red blood cells diffuse into the blood stream from the bone marrow where they can begin to deliver oxygen to tissues. On average red blood cells live for about 120 days. Once the necessary increase in red blood cells has met the oxygen carrying needs of the body, there is a quick negative feedback loop to stop the continuous production of red blood cells. The danger of producing too many red blood cells involves the increase in viscosity of the blood. This increase in viscosity can make it much

harder for the heart to pump blood through circulation, and it can increase the chances of clotting.

II. Cellular Components of Blood: White Blood Cells

White blood cells, also known as leukocytes, do contain nuclei and a set of organelles. They comprise only about one percent of the cellular components of blood, but their function is entirely different from that of red blood cells. These cells serve to protect the body in immune responses to outside pathogens. Leukocytes are classified as either granulocytes or agranulocytes. Granulocytes contain tiny enzyme-filled sacs that are capable of digesting microbes where as agranulocytes do not contain these enzymes. Granulocytes include neutrophils, basophils, and eosinophils. Agranulocytes include monocytes, macrophages, and lymphocytes.

III. Cellular Components of Blood: Platelets

Platelets account for less than one percent of the cellular components of blood and they are the smallest cellular components as well. Also known as thrombocytes, platelets function to stop blood loss in a damaged vessel by forming a platelet plug. They do this by initiating a coagulation cascade in which several platelets aggregate and clump together to form a mesh of fibrin proteins that stops the bleeding and starts the healing process.

IV. Non-Cellular Components of Blood: Blood Plasma

About fifty-five percent of the blood connective tissue is composed of blood plasma. Blood plasma is over ninety percent water, but it does contain non-cellular components called blood plasma proteins. The plasma water bathes the red blood cells in solution and acts as a transport medium for various organic and inorganic substituents. Blood plasma is responsible

for absorbing heat from metabolism and the different kinds of proteins can be responsible for buffering pH changes, transporting other solutes, and can even contribute to clotting mechanisms. Blood plasma additionally contains nutrients, electrolytes, hormones, gases, and various waste products.

Introduction to Blood Vessels

The blood vessels consist of an enclosed system of tubes between the heart and the tissues of the body. There is an estimated length of 60,000 miles if you placed all the vessels end to end. The function of these vessels is the transportation of blood from the heart to the tissues and back to the heart again. The blood is responsible for transporting oxygen and other nutrients to the tissues, and the heart is in control of moving the blood throughout the body as the pressure generator. Thus, the vessels are the transportation systems used to circulate blood to each and every cell through a variety of blood vessel sizes and pressure gradients.

I. Basic Structure of a Blood Vessel and Components of Blood Flow

There are three structural layers of a blood vessel and each are composed of different tissues. The tunica interna is the innermost tissue, followed by the tunica media in the middle, and the tunica externa on the outside as seen in Figure 9.

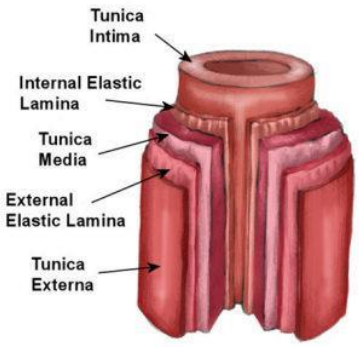


Figure 9. Layers of a Blood Vessel

The tunica interna is the innermost lining of the blood vessel and experiences direct contact with blood. Its lining is composed of endothelium, which is the same lining of the interior heart wall.

The smooth muscular layer of the blood vessel is the thickest layer and is known as the tunica media. It contains elastic fibers that can regulate the diameter of the vessel and can control the amount of pressure used to pump blood through specific tissue regions. Decreasing the diameter of a vessel from the contraction of smooth muscle is known as vasoconstriction, which involves an increase in blood pressure usually as the result of sympathetic nervous stimulation. In contrast, opening the diameter of a vessel is referred to as vasodilation and corresponds with a relaxation of the smooth muscular layer. The pressure gradient generated by the smooth muscular contractions is directly proportional to the flow rate of the blood through a vessel. Thus, the flow rate would be inversely proportional to vascular resistance. The resistance of blood can depend on the viscosity of the blood, the length of the vessel, and the radius of the vessel depending on the pressure. An increase in resistance corresponds to an increase in viscosity, an increase in vessel length, and a decrease in vessel radius.

The tunica externa mostly consists of collagen fibers that are used to help anchor the exterior parts of vessels to surrounding tissues.

II. Arteries

Arteries are the vessels that direct blood moving away from the heart towards the tissues of the body. In the systemic circulation, arteries always contain oxygenated blood as they branch

into arterioles and smaller vessels known as capillaries for oxygen and nutrient delivery. However, in pulmonary circulation, arteries contain deoxygenated blood moving out of the right ventricle and leading to the lungs for oxygenation. Arteries act as pressure reservoirs that can manage large amounts of pressure coming from the ejection of blood into systemic circulation due to their highly elastic properties. Their walls contain elastic properties from the elastin protein and strength due to the presence of collagen.

III. Blood Pressure

Blood pressure is a measure of force exertion by the blood against the walls of a blood vessel. Its factors depend on the volume of blood within the vessel and the compliance of the vessel's walls. Compliance is a measure of how easily the vessel can be stretched. Measured in the arteries, blood pressure is at a maximum value when blood is ejected from the left ventricle into systemic circulation during systole, also known as the contraction phase of the heart. Generally, this value averages around 120 mmHg. The lowest value of pressure within the arteries comes during diastole, or the relaxation phase of the heart when the exertion of blood is not as forceful. This blood pressure value averages around 80 mmHg.

IV. Arterioles

Arterioles are also known as resistance vessels due to their ability to change diameter from contractions of smooth muscle. Their ability to vasoconstrict or vasodilate allows certain tissues to receive significantly different amounts of blood based off of the distribution of cardiac output. Increasing the diameter of these vessels allows a greater rate of blood flow to tissues, whereas decreasing the diameter would decrease the flow rate. Arterioles contain very little amounts of elastic connective tissue.

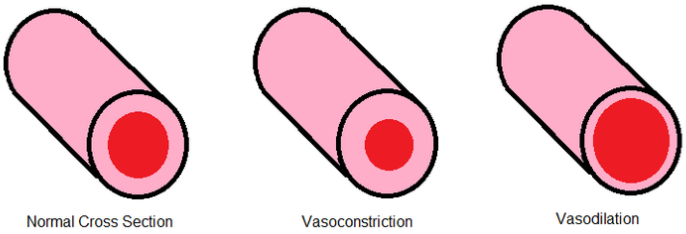


Figure 10. Blood Vessel Pressure Gradients

V. Capillaries

Capillaries are the smallest blood vessels in terms of diameter. Branching off in between arterioles and venules, they are known as exchange vessels that transfer oxygen, carbon dioxide, and nutrients between the vascular system and the surrounding tissues.

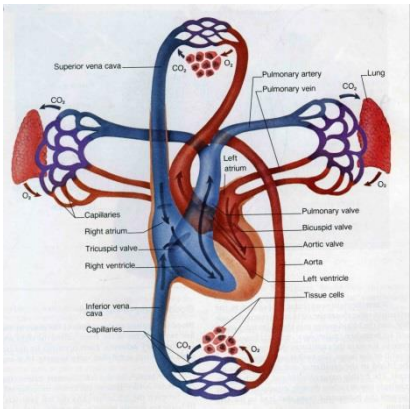


Figure 11. Capillary Exchange in Systemic Circulation

These vessels specialize in the transfer of substances via diffusion. Due to the extremely high numbers of capillaries in the body (somewhere between 10 and 40 billion), diffusing molecules are not forced to travel large distances between vessels and tissues. Their foundation consists of a thin endothelial lining that enhances the ease for diffusion. Additionally, the thin diameter allows the slow process for exchange. In other words, the diameter becomes small enough to fit just one red blood cell through at a time to enhance the rate of exchange.

VI. Veins

After the blood has exchanged gases and nutrients with the tissues in the capillaries, it begins its route back to the heart through the veins. Veins are known as volume reservoirs due to their ability to hold large amounts of blood, generally sixty percent of the blood volume at rest. They have a larger radius and a smaller resistance than arteries. They contain thin walls with little elasticity, but a good amount of compliance. Additionally, veins possess venous valves that prevent the back flow of blood, similar to those found in the heart.

VII. Coronary Circulation

Just like any other tissue, the heart requires oxygen and nutrient delivery from blood. Although blood flows through the chambers of the heart, this does not facilitate a supply of nutrient and gas diffusion. Therefore, the heart possesses its own set of arteries branching off of the ascending aorta from the systemic circulation. These arteries are called the coronary arteries and are responsible for supplying the cardiac tissue with oxygenated blood. During diastole, the heart relaxes which allows blood to flow through the open coronary arteries and perfuse the muscle tissue. Some of the primary coronary arteries include the anterior interventricular branch, which supplies blood to the walls of both ventricles. The posterior interventricular branch supplies the ventricles on the posterior side of the heart. The circumflex branch provides blood for the walls of the left ventricle and left atrium. The marginal branch connects to the right ventricle. The left coronary artery supplies blood to the left atrium and the right coronary artery delivers blood to the right atrium.

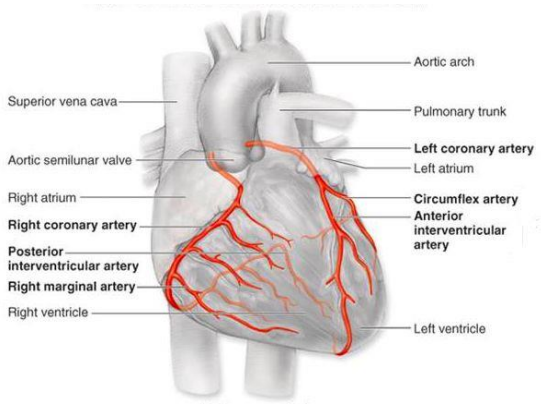


Figure 12. Coronary Artery Circulation

In coronary circulation, the heart can be perfused by more than one artery at the same connection site in the vasculature. This kind of connection is called an anastomoses, which provides an alternate route for blood perfusion through collateral vessels. If a main route in the coronary arteries experiences an obstruction to blood flow, it is common for the coronary arteries to have a kind of backup plan in the form of collateral circulation for the myocardium. It is essential that the heart receives oxygen and nutrient delivery in each beat to keep the heart pumping for the entire body. Collateral circulation is ultimately a method to detour a disruption in blood flow.

Introduction to Coronary Artery Disease

Cardiovascular (CV) disease is classified as any disease that affects the heart or the blood vessels. Since the cardiovascular system contains such a broad array of structures, there are numerous risks and associated defects included in CV disease. Quite often, CV disease occurs in relation to atherosclerosis, which is plaque buildup on the interior walls of the arteries. Not only does this force the heart to work harder to pump blood through the narrowing vessels, but it increases the chances of clotting and stopping blood flow altogether.

The prevention of blood flow and oxygen delivery to the heart is known as myocardial ischemia. Eventually, this can lead to myocardial infarction, which is cell death commonly known as a heart attack.

CV disease can take the form of many different types of disorders. Its deadliest sub-category is known as Coronary Artery Disease (CAD), which is the leading cause of death in the world. More than 13 million Americans alone are affected by this disease and annually it causes almost 400,000 American deaths, which is 18 percent of total deaths in the United States (World Health Rankings). Additionally, there is a reported 1 million new cases of CAD every year worldwide. CAD is ultimately a result of atherosclerosis, specifically in the coronary arteries. When the coronaries can no longer deliver blood to the heart in a conventional manner, the heart's pumping ability quickly becomes impaired. Thus, CAD, myocardial ischemia, and myocardial infarction combine to form a pathophysiologic continuum by preventing the heart from properly pumping blood due to the loss of oxygen and nutrient delivery.

I. Non-modifiable Risk Factors of CAD

The risks that increase the chances of acquiring coronary artery disease include a variety of factors. These factors can be classified as either modifiable or non-modifiable. The non-modifiable risk factors are circumstances in which the patient cannot alter or control. For example, the risk of obtaining CAD can increase with advanced age. Men over the age of 45 and women over the age of 55 are at an increased risk for CAD.

Additionally, gender plays a role as well. Men are at a greater risk for CAD than women and they have an increased chance of experiencing myocardial infarction earlier in life, which is why their risk for CAD is at an earlier age than women.

Race and ethnicity must be taken into account as well. For example, African-Americans experience a greater risk for heart disease due to their rates of high blood pressure, diabetes, and obesity.

One of the biggest non-modifiable risk factors is due to genetics. A family history of CAD can put an individual at risk depending on which relatives possessed the disease. Children with a first degree relative who acquired CAD are at a greater risk of developing it themselves. For example, a child with a father or a brother who acquired CAD before the age of 55 has an increased chance of developing the disease as well. A child with a mother or a sister who acquired CAD before the age of 65 is also at a greater risk to develop the disease. It is important to keep in mind that these risk factors are simply non-modifiable, though some of the risks that go into family genetics are due to higher blood pressure, diabetes, obesity, etc. These risks are modifiable.

II. Modifiable Risk Factors of CAD

Modifiable risk factors of CAD are factors that can be controlled to reduce the risk of developing CAD by making lifestyle changes. Between 80 and 90 percent of people who have been diagnosed with CAD have at least one modifiable risk factor. Modifying these factors can have a dramatic impact of reducing the risk for acquiring CAD. There are several modifiable risk factors that are widely known to have an effect on CAD: dyslipidemia, hypertension, cigarette smoking, diabetes or insulin resistance, obesity, sedentary lifestyle, and an atherogenic diet.

1) Dyslipidemia

Dyslipidemia is known as an abnormal amount of plasma lipoproteins in the bloodstream. For the most part, this risk for CAD is associated with an abnormally elevated amount of lipids, phospholipids, cholesterol or triglycerides. Ideally, less than 200 mg/dL of total cholesterol is desirable for a healthy lifestyle. More than 240 mg/dL can triple the risk for CAD, and it becomes much more difficult to modify this risk as cholesterol levels elevate.

High density lipoproteins (HDL), also known as "good cholesterol," can protect the heart against heart disease by acting as a reverse cholesterol transport mechanism. HDL returns lipids that are stuck on the endothelial lining of blood vessels back to the liver for metabolism. Over 60 mg/dL is considered ideal for HDL levels and is considered protective against CAD. Low levels of HDL can increase the risk for CAD, but HDL levels can increase due to exercise, weight loss, fish oil supplementation, and moderate alcohol consumption.

Low density lipoproteins (LDL), also known as "bad cholesterol," are responsible for delivering cholesterol to the tissues. However, excessive LDL end up sticking to the endothelial cells of the arteries, which can result in clotting and higher blood pressure that can lead to an increased risk for CAD. Less than 100 mg/dL of LDL is considered optimal. Anything over 160 mg/dL can put an individual at a higher risk for CAD.

Triglycerides are other types of lipoproteins that are used as an energy source for metabolism through oxidation. Normal levels of triglycerides include ranges under 150 mg/dL, while 200-400 mg/dL is considered high and at risk for CAD.

2) Hypertension

Hypertension, or high blood pressure, is an increase in the exertion of blood pressure against the walls of an artery. Normal resting systolic blood pressure remains around 120 mmHg, while normal resting diastolic blood pressure ranges to about 80 mmHg or below. An individual is said to be pre-hypertensive between the ranges of 120-139 mmHg for systolic blood pressure and 80-89 mmHg for diastolic blood pressure. The stages of diagnosed hypertension range from 140 to anything above 160 mmHg for systolic blood pressure, and from 90 to anything above 100 mmHg for diastolic blood pressure. Since hypertension can be associated with atherosclerotic diseases and plaque buildup, it is an indication for severe risk for CAD.

3) Cigarette Smoking

The connection between cigarette smoking and CAD can be traced back to the toxic chemicals that tobacco leaves behind in the bloodstream. These chemicals damage the structure of blood vessels and the function of the heart, which can lead to atherosclerosis. Twenty-one percent of mortalities from CAD are directly connected to cigarette smoking. However, smoking is a modifiable risk factor, and the risk of CAD can be reduced if smoking is stopped. The risk for CAD can decrease by as much as 50 percent in one year without smoking.

4) Diabetes and Insulin Resistance

There are 21 million people living with diabetes in the United States alone. Diabetes is a disease that is associated with the chronic metabolic disorder of hyperglycemia, also known as high blood glucose. Insulin is a hormone produced by the pancreas that is responsible for removing glucose from the blood and transporting it into cells of different tissues. In diabetes, either the pancreas cannot produce insulin properly or the pancreas produces too much insulin

and the cells of the body become resistant to insulin signaling. Both cases involve hyperglycemia, which can be harmful due to high blood sugar leaving fat deposits in blood vessels and resulting in atherosclerosis. Individuals with diabetes are twice as likely to develop CAD or ischemic heart disease and many are at risk for heart attack and stroke at a much earlier age.

5) Obesity and Sedentary Lifestyle

Obesity is defined as an excessive amount of weight that is considered unhealthy for an individual's specific height. In the United States, it is estimated that 65 percent of the adult population is either overweight or obese, which puts them at a greater risk for CAD. Obesity can be caused by a variety of factors including environmental conditions, genetics, family history, and lifestyle habits. These habits often involve sedentary activities and an unhealthy diet, which raises the risk for atherosclerosis and cardiovascular disease. The rise in obesity and sedentary lifestyles are often connected with Type 2 diabetes as well. Most of these modifiable risk factors are associated with each other due to an atherogenic diet and poor lifestyle habits. Dyslipidemia, hypertension, and insulin resistance are often results of obesity and sedentary lifestyles. Therefore, the outcomes of a poor, but modifiable lifestyle become risk factors and indicators for CAD and other cardiovascular diseases.

III. Myocardial Ischemia

The pathophysiologic continuum of CAD starts with the elevated risk for atherosclerosis due to poor control over the modifiable risk factors. As the atherosclerotic plaque builds up within the coronary arteries, the impairment of blood flow becomes problematic in keeping up with cellular metabolism of the myocytes. If the supply of oxygen and nutrient delivery to the

myocardium cannot sufficiently match the needs of the myocytes' cellular metabolism, myocardial ischemia begins to develop. An increase in size of atherosclerotic plaque leads to a greater limitation in coronary blood flow, which can lead to ischemia, especially during exercise.

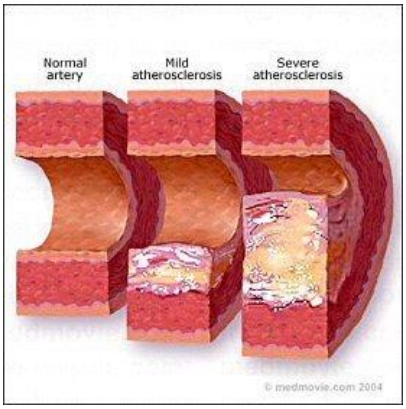


Figure 13. Atherosclerosis

Within ten seconds of coronary occlusion, myocardial become deprived of the necessary supply of coronary blood as ischemia sets in. Several minutes of this continuum leads to a decrease in cardiac output as heart cells can no longer contract because of the loss of oxygen. Under these ischemic conditions, the myocardial cells are not yet dead and they do remain viable for approximately twenty minutes. Often individuals can sense myocardial ischemia from coronary obstruction that causes chest pain. This is referred to as stable angina, which can last approximately three to five minutes. There are occurrences when ischemia cannot be detected by the individual because chest pain is not prevalent. Without this angina, this condition is referred to as silent ischemia and it can be caused by nerve damage in which the individual cannot sense the pain.

IV. Myocardial Infarction

As the pathophysiologic continuum worsens, myocardial ischemia develops into necrosis of the myocytes deprived of a normal blood supply. The death of cardiac muscle cells is a product of ischemia, and without the pumping ability of the myocytes, the heart fails to properly contract. The final part of this pathophysiologic continuum is referred to as myocardial infarction, commonly known as a heart attack. In CAD, a coronary arterial occlusion can include several factors that may be responsible for the infarction. For example, the atherosclerosis can lead to an acute plaque rupture, thrombotic platelet activation, and then a vasospasm or sudden blood vessel constriction.

The sequence of myocardial infarction begins with an alteration in the plaque of a coronary artery. Followed by the vasospasm, there is a formation of platelet aggregation that causes an impairment of blood flow to the heart cells. The duration of the occlusion is not enough to determine the prognosis of the infarction. For example, the exact location of the occlusion, the size of the platelet aggregation, the metabolic needs of the myocardium at the specific time, and the rate of the development of the blockage can all have an important impact on the severity of the infarction. The degree of damage due to the infarction depends on these factors that define the amount of necrosis that took place in addition to how long the interval between infarction and medical intervention lasted.

Introduction to Prevention and Treatment of CAD

The diagnosis for CAD begins with a physical examination that detects possible signs for atherosclerotic disease, which could lead to an ischemic attack. Examinations look for a variety of symptoms that indicate a development of ischemia by evaluating the heart and the

modifiable risk factors associated with CAD. Some examinations include electrocardiography (ECG) to diagnose any irregular heart waves that may be associated with myocardial ischemia. An extra heart sound, such as left ventricular gallop, which follows the normal "lub-dub" sound from the closure of the heart valves, may also be an indicator for heart failure due to impairment of the left ventricle. Turbulent sounds in the carotid arteries, known as carotid arterial bruits, are likely signs of atherosclerotic disease as well. Additionally, physicians look for the presence of xanthelasmas, which are small fatty growths around the corneas of the eyes. These fat deposits suggest evidence for high LDL levels and signal the possible development of dyslipidemia, a known risk factor for CAD.

I. Treatment for Myocardial Ischemia

The treatment for CAD would ideally begin with prevention by making the appropriate lifestyle adjustments to the known modifiable risk factors before CAD diagnosis. Once diagnosis has been confirmed, however, physicians aim to treat myocardial ischemia before patients experience infarction. The treatment of ischemia can involve a variety of medications to enhance blood flow back to the heart, which depend solely on the extent of the ischemic condition.

1) Nitrates

Nitrates are medications given to increase the amount of oxygenated blood the heart will receive through its coronaries due to vasodilation. The increased oxygen and blood supply allows the heart to undergo a more relaxed state rather than work under severe conditions just to reach its required amount of blood flow.

2) Beta-Blockers

Beta-adrenergic receptors have the impact of increasing blood pressure, heartrate, and the amount of work the heart puts in for contraction. Beta-blocking agents are medications used to block these receptors, which can slow down the heartrate and decrease blood pressure. This effect allows blood to flow more easily back to the heart, which permits increased oxygen supply and a lower myocardial demand.

3) Calcium-Channel Blockers

The pace of the heart can be slowed by blocking the influx of calcium into the heart's myocardial cells, thus slowing down the activity of the sinoatrial and atrioventricular node, which can relax the heart and diminish its workload. These calcium blockers also have the effect of relaxing blood vessels and allowing more blood flow back to the heart.

4) Anti-Platelet Agents

The aggregation of platelets in the coronary vessels has the effect of decreasing blood flow and enhancing the risk for ischemic heart disease. Using anti-platelet agents, the aggregation can be reduced, thus decreasing the atherosclerotic disease.

5) Percutaneous Coronary Intervention (PCI)

In cases of narrowed coronary vessels, a surgical procedure allows a stent to be placed within the vessel to increase dilation. This reduces the risk of vessel blockage and allows more blood flow back to the heart. Some stent procedures involve antithrombotic treatments, which include glycoprotein receptor antagonists that can further decrease the risk of atherosclerotic disease.

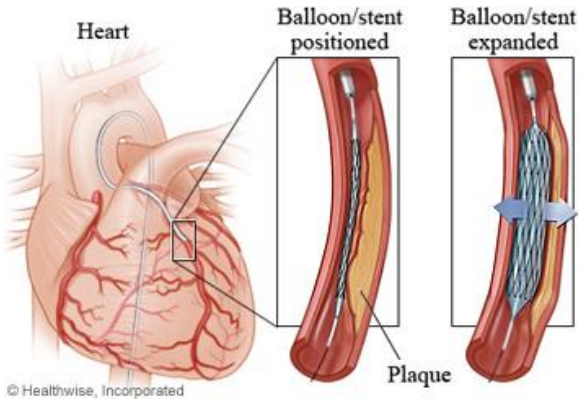


Figure 14. Percutaneous Coronary Intervention

6) Coronary Artery Bypass Graft (CABG)

In severe cases, a CABG can be used to surgically treat ischemic heart disease. The procedure typically involves the removal of the saphenous vein from the leg of the patient, which is then used as a bypass graft from the aortic arch to the heart. This increases blood flow to the heart as well as its oxygen supply.

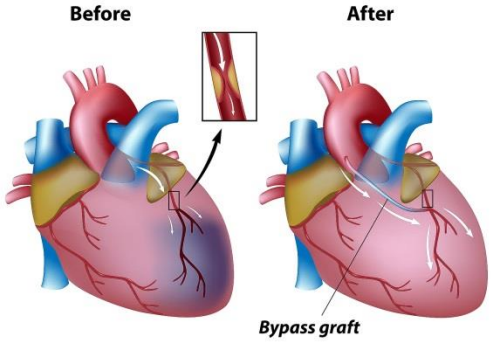


Figure 15. Coronary Artery Bypass Graft

II. Treatment for Myocardial Infarction

Treating CAD in the myocardial infarction stage is less of a prevention and more of an effort to save the patient's life. Infarction is the process in which an occlusion prevents blood flow

back to the heart, thus causing biochemical and functional damage to the myocardium. Modification of this damage typically involves initial restoration of perfusion to save the heart muscle and to reestablish proper myocardial contraction. The reperfusion can be induced by PCI, CABG, or other surgical means. Further complications depend on the size, location, and extent of the necrosis in the myocardium. In order to prevent another infarction incident, there must be a restoration of reliable oxygen supply to reestablish the balance between oxygen supply and demand.

Introduction to CAD Statistics in the United States

Coronary artery disease affects more than 13 million Americans and is responsible for almost 400,000 deaths in the U.S every year. Not only is it the leading cause of death in the United States, but it kills more people worldwide than anything else. According to the World Health Rankings, the United States ranks 107th out of 172 countries in CAD associated deaths per 100,000 of population. The age adjusted death rate is 77.97 per 100,000 individuals. This marks CAD as responsible for 18.06% of annual deaths in the U.S.

There are a number of risk-factors that are associated with CAD, therefore the prevalent causes of CAD in the United States may not be the same causes of CAD in other countries around the world. Modifiable risk-factors such as obesity, diabetes, and rates of smoking can vary due to nutritional, economic, and cultural differences between nations. This may explain why some countries experience a much higher rate of CAD associated deaths than others.

1) Dyslipidemia

In the United States, there are more than 73.5 million adults with high levels of low-density lipoprotein (LDL) cholesterol. This represents about 31.7 percent of the adult population. Approximately one out of three adults with high LDL has their condition under control, whereas only 48.1 percent actually seek treatment. Thirty-one million of these adults possess total cholesterol levels above 240 mg/dL. High total cholesterol levels can put an individual at twice the risk for developing heart disease, and while treatment of LDL has increased from 28.4 percent to 48.1 percent of American adults between 1999 and 2008, high LDL levels have only gone down by 2 percent. However, total cholesterol levels have dropped for Americans from 18.3 percent to 12.9 percent between 1999 and 2012. Though the progress is slow, securing control over dyslipidemia not only prevents complications with CAD, but it prevents other risk factors such as hypertension from worsening.

2) Hypertension

About 70 million adults in the United States have high blood pressure. High blood pressure in this case is defined as having a systolic blood pressure above 140mmHg and a diastolic blood pressure above 100mmHg. This hypertensive statistic represents about a third of the adult population. Approximately 52 percent of people with hypertension have the condition under firm control. Additionally, about one out of every three American adults is pre-hypertensive, meaning they possess systolic blood pressures between 120 and 139mmHg along with diastolic blood pressure between 80 and 99mmHg. According to the data from the 2014 World Health Rankings, hypertension was responsible for 71,304 deaths in the United States, which was about 3.27 percent of total deaths in the U.S. Hypertension is linked closely as a contributor to

heart attacks being that 70 percent of people experiencing a heart attack for the first time also have high blood pressure.

3) Cigarette Smoking

There are an estimated 40 million U.S. adults who smoke cigarettes, which is about 16.8 percent of the American adult population. The CDC defines current smokers as individuals who have smoked more than 100 cigarettes in their lifetime in addition to reporting as smoking every day or some days at the time they were surveyed. Cigarette smoking can be attributed to one in every five deaths, and is known as the leading cause of preventable deaths in the U.S. There are also 16 million Americans currently living with smoking-related diseases, such as CAD, lung cancer, and lung disease. Though the rates of smoking have dramatically declined in the last 50 years, progress is still being made. Smoking rates have declined from 21 out of every 100 American adults in 2005 to less than 17 out of every 100 adults in 2014 (CDC).

4) Diabetes and Insulin Resistance

Approximately 21 million American people have been diagnosed with diabetes. Additionally, there is an estimated 8.1 million people who have not been diagnosed and are currently living with diabetes. In total, over 29 million Americans are believed to be living with diabetes, which accounts for about 9.3 percent of the population. Additionally, there are approximately 86 million Americans who are currently living with pre-diabetes, which means one out of every three adults is considered to be pre-diabetic. Nine out of ten people do not know they are pre-diabetic while one out of four does not know they have diabetes. It is estimated that 15-30 percent of American adults who are considered to be pre-diabetic will develop Type 2 diabetes within 5 years. Type 1 diabetes in adults accounts for just 5 percent of

all diabetes diagnoses in the United States. This means that one out of every three adults will likely develop Type 2 diabetes in their lifetime. In 2014, over 71,000 people died from diabetes in the United States, which accounted for about 3.28 percent of total American deaths (WHO).

5) Obesity

In the United States, over 78.6 million adults are considered obese, which accounts for almost 35 percent of the U.S. adult population. Generally, people are designated obese based on their Body Mass Index (BMI), which compares a person's weight and height. For example, a male who measures 69 inches in height would be expected to weigh between the ranges of 125 to 168 pounds. This gives a BMI score of 18.5 to 24.9 for a healthy weight. Between 169 and 202 pounds would be considered overweight, while anything above 202 pounds would be considered obese for a 69-inch tall male. A BMI score of 30 or higher generally indicates obesity, though a BMI score cannot measure the percentage of body fat directly. According to a global study done by the CIA in 2008, the United States ranked 18th in the world on the list for most obese countries. This marks the highest ranked risk factor for the United States in comparison to dyslipidemia, hypertension, cigarette smoking, and diabetes.

Introduction to CAD Statistics in France

In France, Coronary Artery Disease causes almost 40,000 deaths per year. It amounts to 9.66% of all deaths in France, though it is not the leading cause of death for the French. Lung cancer remains the number one cause of death while CAD places second. According to the World Health Rankings, the age adjusted death rate for CAD in France is 29.97 per 100,000 individuals, which ranks France 171st out of 172 countries listed.

The prevalence of the modifiable risk factors associated with CAD vary between France and the United States, which could partially explain the significant difference in the percentage of deaths caused by CAD between the two countries.

1) Dyslipidemia

According to the World Health Organization, it is estimated that France possesses a 62% prevalence of raised blood cholesterol that is greater than 5.0 mmol/L. This data does not indicate whether this is representative of total blood cholesterol or low-density lipoprotein cholesterol. Although the CDC estimates the United States as having a raised blood cholesterol rate of 31 percent, the data from the World Health Organization estimates the United States as having a raised blood cholesterol rate of over 53 percent. Both data collections do indicate that France has a much higher level of raised blood cholesterol.

2) Hypertension

Approximately 26.3% of the adult French population possesses high blood pressure. High blood pressure in this case is defined as having a systolic blood pressure above 140 mmHg and a diastolic blood pressure above 90 mmHg. The United States does have a higher rate of hypertension than France, which is steady at about 30% of the adult population compared to France's 26.3%. According to the World Health Rankings, hypertension was the cause of almost 11,000 deaths in France during 2014, which represented about 2.58% of deaths for the French. Hypertension is ranked as the 16th most common cause of death in France, whereas in the U.S. it is ranked as the 9th most common cause. Additionally, France was ranked 154th out of 172 countries for deaths resulting from hypertension and the United States was ranked 105th.

Though both countries have similar percentages of people living with hypertension, the U.S. shows a significantly greater amount of hypertensive related deaths.

3) Cigarette Smoking

There are an estimated 14-16 million smokers in France. Approximately 29.8% of the adult male population and 25.6% of the adult female population smokes cigarettes regularly as of 2015. These averages greatly exceed the 14-17% of American adult smokers. Although the French possess one of the highest rates of cigarette smoking in Europe, there has been a decline in total cigarette smokers in France within the last decade. In 2005, over 34% of adult males and 26% of adult females smoked cigarettes. Additionally, cigarette smoking has played a large role in developing lung cancer in France, which is the most common cause of death for the French.

4) Diabetes and Insulin Resistance

Approximately 3.7 million people in France have been diagnosed with diabetes. It is estimated that between 600,000 and 700,000 additional people in France do not know that they have diabetes. In total, 1 in 16 adults in France has diabetes, which represents over 6% of the adult population and each day there are 400 new cases of diagnosed diabetes. Of those that have been diagnosed, 16.7% experience cardiovascular troubles. Overall, diabetes is the 12th leading cause of death in France, which accounts for 2.90% of all deaths. The French rank 150th out of 172 countries for mortalities resulting from diabetes. Compared to the United States, France possesses a slightly smaller percentage of people who have been diagnosed with diabetes and/or do not realize they have diabetes. The United States has an approximate 9.3% diabetic population with an estimation of 86 million people living with pre-diabetes. France does not

have an exact estimation for how the amount of people living with pre-diabetes, but 33% are said to be at risk for developing diabetes.

5) Obesity

In France, it is estimated that 15.1% of all women and 13.9% of all men are obese. Overall, approximately 6.5 million people in France are considered to be obese, which represents about 14.5% of the population. From 1997 to 2009, the prevalence for obesity climbed 6% in France from 8.5% to 9.5%. In the United States, 35.8% of all women and 33.3% of all men have been diagnosed with obesity with an overall amount of over 78 million people. This statistic shows the most significant difference in the comparison between the CAD modifiable risk factors for the two countries. In 2008, a CIA study showed that France was ranked 108th in the world for prevalence of obesity, while the United States was ranked 18th.

Conclusion

The amount of deaths associated with Coronary Artery Disease in the United States greatly outweighs the amount of CAD related deaths in France. More than 18% of all deaths in the U.S. are due to CAD, while in France, that statistic is reduced to just 9%. Thus, the United States is ranked 107th for the highest percentage of CAD related deaths by the World Health Rankings.

According to the statistics of the modifiable risk factors, the United States and France contain different data depending on the category of risk factor. Both countries possess similar data for hypertension and diabetes, but it is clear that dyslipidemia, cigarette smoking, and obesity represent wide differences between the two countries.

Dyslipidemia in the United States is estimated to be prevalent in more than 31% of adult individuals by the CDC. However, this number is raised to more than 53% by the World Health Organization. The WHO also estimates France to possess a raised blood cholesterol level of more than 62%. According to this data, France has a much higher rate of dyslipidemia than the United States.

Hypertension is relatively equal in both countries. In the United States, about 30% of adults are considered to be hypertensive and 26.3% of adults in France have hypertension.

Cigarette smoking is much more common in France than in the United States. Between 26-29% of adults in France smoke cigarettes, whereas the United States contains between 14-17% of adults who smoke cigarettes.

Diabetes is also relatively similar in both countries. The United States represents a slightly higher level of diabetes at 9.3%. France is estimated to be about 6%.

When it comes to obesity, the United States clearly has a higher rate of obese adults at about 35%. France has an obese level of just 14.5%. This could further suggest that France has a much less sedentary lifestyle than the United States.

Overall, levels of high cholesterol are much higher in the French as well as cigarette smoking. With diabetes and hypertension at relatively equal amounts in both countries, this raises the question as to why CAD is so much more deadly in the United States. The one risk factor that justifies this comparison is obesity. With over 35% of the American adult population being obese, just 14.5% of the adult French population has been diagnosed with obesity. This indicates an explanation as to why France has a much lower rate of CAD than the United States.

The data suggests that doubling the obesity rate could possibly explain why the United States has twice the amount of deaths associated with CAD.

What Can We Learn from France?

The statistics of CAD indicate that obesity is a primary factor in causing CAD related deaths. With obesity being much lower in France, there is an implication that the United States lives a much more sedentary lifestyle than the French. Exercise and activity levels are clearly essential in reversing obesity and heart disease. While maintaining a healthy weight and living an active lifestyle are important steps in reducing CAD, there are other theories that point out the significantly low rates of CAD in France.

The "French Paradox" discusses several possibilities that could lead to explanations of why France is more protected from cardiovascular disease than other countries despite France's high consumption of saturated fats and its high levels of blood cholesterol. Most of the French Paradox points back to the fact that France lives a much more relaxed lifestyle. For example, France has just a 35 hour work week, which gives adults much more time to relax and provides a more stress-free environment. Additionally, in the culture of France, eating is seen as a social event. People eat all day, but they eat in a more relaxed setting compared to adults in the United States who are known to consume food much faster to simply satisfy their appetites. The French Paradox is not a proven explanation as to why France possesses a lower rate of cardiovascular disease than other countries, but it does provide insight as to how a less stressed environment can further protect people from cardiovascular disease.

Appendix A: Personal Observations in France

As a student who studies French in addition to physiology, I took the opportunity to study abroad during the summer of 2015 in Paris, France. While taking two French courses through faculty taught by the University of Arizona for six weeks, it was arranged that I live with a French host family and gain a first-hand experience of French culture and society. Many of my experiences involved my exploration of France and my personal observations in the daily lifestyle as an individual who lived in Paris. In relation to my comparison of CAD between France and the United States, I was able to make several different observations regarding the eating habits, activity levels, and the social lifestyles of the French.

The French diet primarily consists of carbohydrates and saturated fats. My host family cooked dinner every night with fresh bread, fresh vegetables, several different kinds of cheese and butter dishes, in addition to ham being the primary source of protein. Most of the dishes cooked at home seemed very lean and light, but also very filling. There was a limited amount of sweets kept in the house, so overall the meals at home seemed very healthy and fulfilling. In addition to eating with the host family, I was able to explore a variety of cafes that surround the streets in Paris. Each and every one of them sells pastries and baked sweets, which I could tell were very popular among the citizens. It wasn't uncommon to find unique cafes that had multiple selections of pastries, crepes, and other dishes that seemed very high in saturated fat content. However, the biggest difference between France and the United States is the amount of fast-food restaurants. In the U.S. it is easy to find multiple fast-food places on a single block, but in France, there are very few fast-food restaurants, other than the occasional McDonalds.

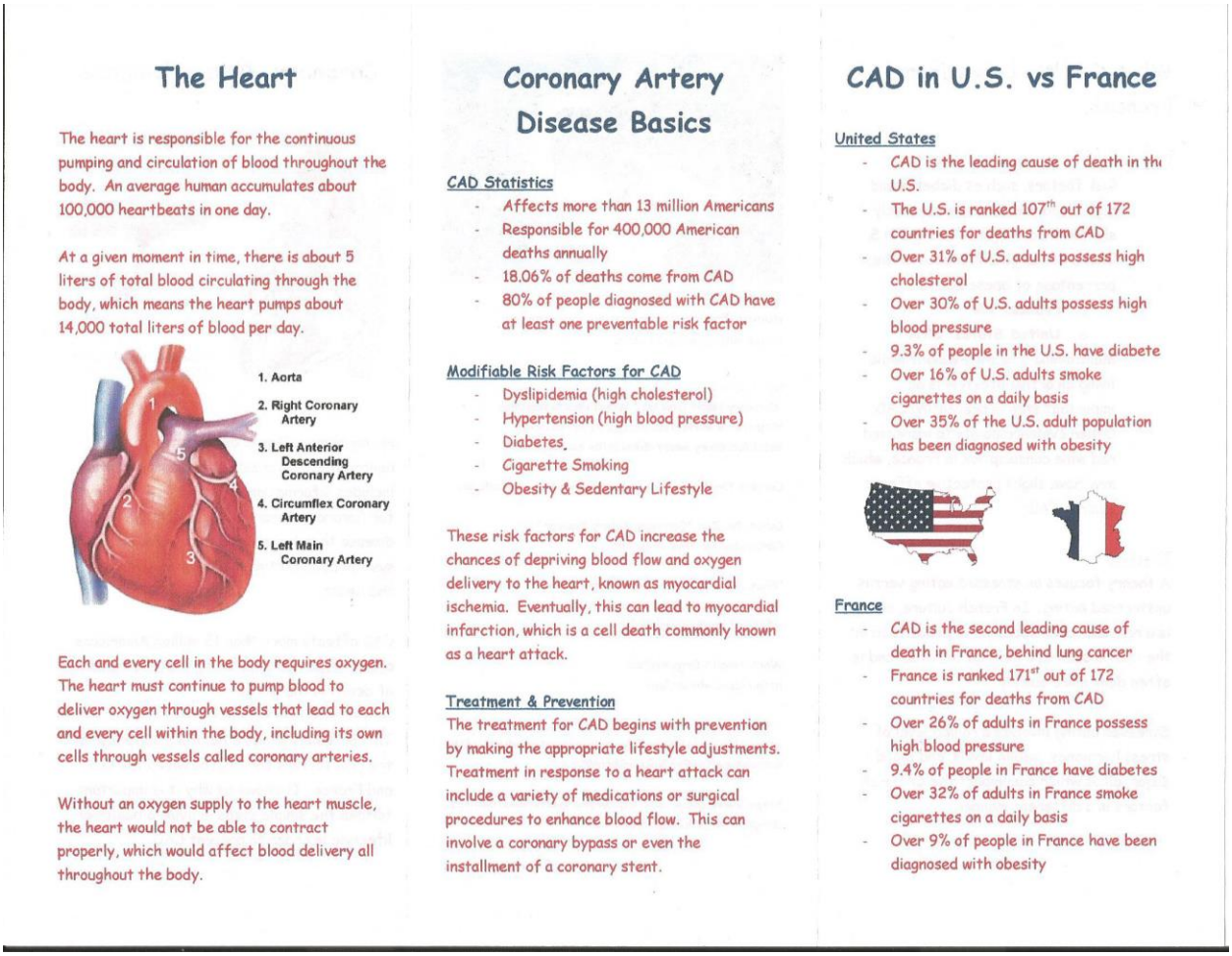
In France, being active is not something that an individual has to work at. Everywhere I went, walking was my primary mode of transportation. It was not uncommon for me to walk more

than ten miles in one day between going to school, to and from the metro, and the grocery market. In addition to all of the walking, I had a gym membership. However, going to the gym is not very popular among the French. Most of the time, the gym was empty with limited amounts of equipment. However, there were very few overweight people in France. Most adult men and women were fairly slim, which explains why they only have a 14.5% obesity rate.

The social lifestyle of the French is very relaxed. French citizens always seemed very calm and stress free. They work a maximum of 35 hours per week, and they love their socializing time outside the cafes. Although they eat a large amount of food throughout the day, they see eating as a social event, which possibly keeps their meal time stress free and more relaxed. Even with all of the rich food I consumed, at the end of my study abroad program, I had lost nine to ten pounds. My overall experience in Paris exemplified this relaxed social setting by peacefully eating meals with classmates, sitting outside cafes with pastries and coffee, and drinking wine by the Eiffel Tower.

Appendix B: Tucson Festival of Books

During the 2016 Tucson Festival of Books, I was given the opportunity to volunteer with the University of Arizona Physiology Booth. Along with other honors seniors and volunteers, I educated our visitors with helpful knowledge about the cardiovascular system and how to keep the heart healthy. My thesis was printed out as a pamphlet for any visitors who were interested in learning more about CAD and how to prevent it. Most visitors seemed very pleased to have students wanting to educate them and their kids about how the cardiovascular system is a vital part of life and it is essential to take great care of it.



The Heart

The heart is responsible for the continuous pumping and circulation of blood throughout the body. An average human accumulates about 100,000 heartbeats in one day.

At a given moment in time, there is about 5 liters of total blood circulating through the body, which means the heart pumps about 14,000 total liters of blood per day.

Each and every cell in the body requires oxygen. The heart must continue to pump blood to deliver oxygen through vessels that lead to each and every cell within the body, including its own cells through vessels called coronary arteries.

Without an oxygen supply to the heart muscle, the heart would not be able to contract properly, which would affect blood delivery all throughout the body.

Coronary Artery Disease Basics

CAD Statistics

- Affects more than 13 million Americans
- Responsible for 400,000 American deaths annually
- 18.06% of deaths come from CAD
- 80% of people diagnosed with CAD have at least one preventable risk factor

Modifiable Risk Factors for CAD

- Dyslipidemia (high cholesterol)
- Hypertension (high blood pressure)
- Diabetes
- Cigarette Smoking
- Obesity & Sedentary Lifestyle

These risk factors for CAD increase the chances of depriving blood flow and oxygen delivery to the heart, known as myocardial ischemia. Eventually, this can lead to myocardial infarction, which is a cell death commonly known as a heart attack.

Treatment & Prevention

The treatment for CAD begins with prevention by making the appropriate lifestyle adjustments. Treatment in response to a heart attack can include a variety of medications or surgical procedures to enhance blood flow. This can involve a coronary bypass or even the installment of a coronary stent.

CAD in U.S. vs France

United States

- CAD is the leading cause of death in th U.S.
- The U.S. is ranked 107th out of 172 countries for deaths from CAD
- Over 31% of U.S. adults possess high cholesterol
- Over 30% of U.S. adults possess high blood pressure
- 9.3% of people in the U.S. have diabete
- Over 16% of U.S. adults smoke cigarettes on a daily basis
- Over 35% of the U.S. adult population has been diagnosed with obesity

France

- CAD is the second leading cause of death in France, behind lung cancer
- France is ranked 171st out of 172 countries for deaths from CAD
- Over 26% of adults in France possess high blood pressure
- 9.4% of people in France have diabetes
- Over 32% of adults in France smoke cigarettes on a daily basis
- Over 9% of people in France have been diagnosed with obesity

What Can We Learn from France?

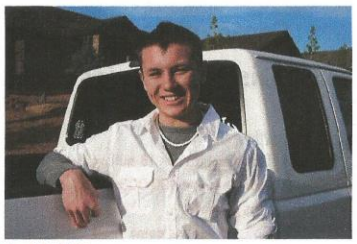
Evidence

- Risk factors, such as diabetes and high blood pressure are relatively similar in both France and the U.S.
- There is a large difference in the percentage of obese adults:
  - **France: 9%**
  - **United States: 35%**
- Maintaining a healthy weight while living an active lifestyle is an important step in preventing CAD.
- Other evidence points to increased red wine consumption in France, which may have slight protective effects against CAD.

Theories

A theory focuses on stressed eating versus unstressed eating. In French culture, eating is a relaxed social occasion, whereas food in the U.S. is seen as a method to refuel and is often done more quickly.

Stressed eating involves a raised level of stress hormones, insulin levels, and blood sugar, all of which can impact the CAD risk factors in a different manner.



Daniel J. Kitts
Honors Physiology
University of Arizona 2016

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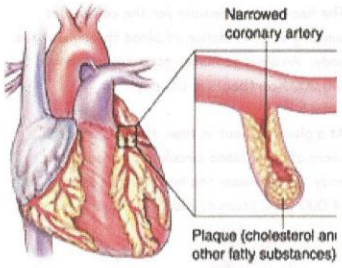
https://www.google.com/#q=coronary+arteries&tbm=isch&imgrc=FW_NW2eQFB2quM%3A

Coronary Artery Disease



Hi, my name is Daniel and as part of my honors thesis, I created this pamphlet that includes information about the risk factors for Coronary Artery Disease (CAD), which is disease that targets the cardiovascular system by affecting the pumping ability of the heart.

CAD affects more than 13 million Americans and is responsible for being the leading cause of death in the world.

This pamphlet shows a helpful comparison of the risk factors for CAD between the U.S. and France. It shows us why it is important to take the simple steps in living a healthier lifestyle in order to prevent CAD.

Appendix C: Physiology Undergraduate Poster Session

Vive La France:
Comparing Heart Health between the US and France

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Abstract

The goal of this study is to investigate the components and differences of the modifiable risk factors for Coronary Artery Disease (CAD) between individuals diagnosed in both the United States and France. The amount of deaths associated with CAD in the United States greatly outweighs the amount of CAD related deaths in France. More than 18% of all deaths in the U.S. are due to CAD, while in France, that statistic is reduced to just 9%. Out of 172 countries, the United States ranks 107th for highest percentage of deaths from CAD, while France ranks 171st. Risk factors that were analyzed and compared include dyslipidemia, hypertension, cigarette smoking, diabetes, and obesity. The majority of these risk factors are comparably similar between both countries with the exception of dyslipidemia and cigarette smoking being slightly higher in France. However, there is a large difference in the prevalence of obesity. The United States possesses a 35% rate of obesity while France averages just 14.5%. While it remains unclear as to why France has a much lower rate of CAD than the US, it is reasonable to speculate that twice the amount of obesity will also double the amount of CAD.

Cardiovascular System

CV System

The heart, blood vessels, and blood encompass the three primary components of the cardiovascular system, which permits the pumping, circulation, and delivery of blood and nutrients to each and every cell within the body.

The Heart

Each and every cell in the body requires oxygen. The heart must continue to pump blood to deliver oxygen through blood vessels that lead to each individual cell within the body, including the heart's own cells through vessels called coronary arteries.

Coronary Arteries

The heart possesses its own set of arteries branching off systemic circulation. Coronary circulation is responsible for perfusion to the cardiac tissue with oxygenated blood. Without perfusion to the heart muscle, the heart would not be capable of properly contracting.

Coronary Artery Disease (CAD)

What is CAD?

- CAD occurs in relation to atherosclerosis, specifically in the coronary arteries. Plaque buildup on the interior walls of these arteries affects blood delivery to the heart, which can quickly impair the heart's pumping ability.
- This deprivation of perfusion to the heart is called myocardial ischemia. The point at which the heart stops contracting, due to impaired perfusion, is called myocardial infarction—commonly known as a heart attack.
- CAD is the leading cause of death in the world and causes approximately 31% of all global deaths throughout the year.
- There are several risk factors that can cause CAD. The modifiable risk factors of interest include dyslipidemia, hypertension, diabetes, cigarette smoking, and obesity.

Risk Factors in US

CAD affects more than 13 million Americans and is responsible for more than 18% of all deaths in the United States. This ranks the U.S. 107th out of 172 countries for deaths from CAD.

Risk Factors

- **Dyslipidemia:** Approximately 31% of adults possess high LDL cholesterol
- **Hypertension:** More than 70 million adults have been diagnosed with high blood pressure, while one-third are in the pre-hypertensive stage.
- **Diabetes:** Over 29 million people are believed to be diabetic, representing 9.3% of the American population.
- **Cigarette Smoking:** It's estimated that over 16% of American adults smoke cigarettes
- **Obesity:** Over 35% of American adults have been diagnosed with obesity.

Risk Factors in France

CAD causes almost 40,000 deaths per year in France, which ranks them 171st out of 172 countries for deaths from CAD. This represents 9% of all deaths in France.

Risk Factors

- **Dyslipidemia:** Approximately 62% of adults have high blood cholesterol.
- **Hypertension:** Over 26% of adults in France possess high blood pressure.
- **Diabetes:** One in 16 adults has been diagnosed with diabetes, representing a little over 6% of the adult population.
- **Cigarette Smoking:** Approximately 28% of the adult population smokes cigarettes.
- **Obesity:** Approximately 14.5% of the adult population has been diagnosed with obesity.

Conclusion

Evidence from Risk Factors

The amount of deaths associated with Coronary Artery Disease in the United States greatly outweighs the amount of CAD related deaths in France. More than 18% of all deaths in the U.S. are due to CAD, while in France, that statistic is reduced to just 9%.

According to the statistics of the modifiable risk factors, the United States and France both possess similar data for hypertension and diabetes.

Cigarette smoking is much more common in France than the United States. Additionally, levels of high cholesterol are much higher in the French. This raises the question as to why CAD is so much more deadly in the United States.

The one risk factor that justifies this comparison is obesity. Over 35% of the American adult population is obese. In contrast, just 14.5% of the adult French population has been diagnosed with obesity. Not only does this indicate an explanation as to why France has a much lower rate of CAD than the United States, but it also provides the possibility that the people in France live in a lesser sedentary lifestyle.

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Image References

- Figure 1: <https://www.google.com/search?q=location+of+the+heart+in+the+thoracic+cavity&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIpLuPm_bpyAIVS-BjCh1KNQLg#imgrc=H_STGjYtekbBhM%3A>

- Figure 2: <https://www.google.com/search?q=anatomical+position+of+heart&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIjKvDsqiUyAIViZWACh0qHQaw#tbm=isch&q=chambers+of+the+heart&imgrc=usQAd5D5wFvrEM%3A>

- Figure 3: <https://www.google.com/search?q=anatomical+position+of+heart&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIjKvDsqiUyAIViZWACh0qHQaw#tbm=isch&q=layers+of+the+heart+wall&imgrc=kDFmvJTZcVISBM%3A>

- Figure 4: <https://www.google.com/search?q=heart+valves&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjp9vCtxMDMAhXDeCYKHaAAAYIQ_AUIBigB#imgrc=SiEy0YYL9pIJaM%3A>

- Figure 5: <https://www.google.com/search?q=location+of+the+heart+in+the+thoracic+cavity&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIpLuPm_bpyAIVS-BjCh1KNQLg#imgrc=H_STGjYtekbBhM%3A>
- Figure 6: <https://www.google.com/search?q=ventricular+contraction&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMI6_SkkKPqyAIVBvRjCh0xmQLN#imgrc=LdQ6DqGVfzvIdM%3>

- Figure 7: <https://www.google.com/search?q=path+of+blood+through+the+heart&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwjlt9aNwMDMAhXH2SYKHZB-DKoQ_AUIBigB#tbm=isch&q=path+of+blood+through+heart&imgrc=g1gefYivg72XNM%3A>

- Figure 8: <https://www.google.com/search?q=red+blood+cell+with+hemoglobin&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwiU6ufBwcDMAhVJOCYKHfx4B44Q_AUIBigB#imgrc=ahqIFM95MFYcIM%3A>

- Figure 9: <https://www.google.com/search?q=layers+of+a+blood+vessel&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAYQ_AUoAWoVChMIhbXBqc_qyAIVFuxjCh04RgvP#imgrc=-OQiwoRCKjd1UM%3A>

- Figure 10: <https://www.google.com/search?q=blood+vessel+vasoconstriction&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&ved=0CAYQ_AUoAWoVChMItoPu9tjqyAIVFB5jCh0g2gxf#imgrc=GsmBgmUdZmGZNM%3A>

- Figure 11: <https://www.google.com/search?q=capillary+exchange+in+systemic+circulation&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi79fW8wsDMAhUGOyYKHbhZAYsQ_AUIBigB#imgrc=Sq042-RIg5IUrM%3A>

- Figure 12: <https://www.google.com/search?q=capillary+exchange&biw=1138&bih=548&source=lnms&tbm=isch&sa=X&sqi=2&ved=0CAcQ_AUoAmoVChMI76SJi9zqyAIVTuNjCh06Owfg#tbm=isch&q=coronary+artery+anatomy&imgrc=srW21c1XoNRo4M%3A>

- Figure 13: <https://www.google.com/search?q=atherosclerosis&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&ved=0ahUKEwjX6o_nyafKAhVH8mMKHbmNDc4Q_AUIBigB#imgrc=QA7eR8_AnQ3NhM%3A>

- Figure 14: <https://www.google.com/search?q=percutaneous+coronary+intervention&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&ved=0ahUKEwi_1Kf_uvXLAhXJLmMKHavvAAAQ_AUIBygC#imgrc=ftY51Vxc1X7PIM%3A>

- Figure 15: <https://www.google.com/search?q=coronary+artery+bypass+graft&biw=1366&bih=657&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwjKluvbu_XLAhUY7GMKHR4zCnMQ_AUIBigB#imgrc=C0xTbdKOYTzqkM%3A>