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Under Pressure! The Circulatory System and Hypertension

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Introduction

According to the National Hypertension Association almost 1 in 4 adults have hypertension. It has been deemed as the "silent killer" because it poses no symptoms. Hypertension often leads to cardiovascular diseases such as heart failure and stroke. The Centers for Disease Control states that the cost for treatment of cardiovascular related diseases will approach $77 billion dollars in the US. [1] In fact, among minority populations the rates of hypertension and cardiovascular disease are even higher than the national average. High rates in these populations appear to be due to a lack of understanding of the how hypertension affects the body among many minority persons as well as a failure of individuals to seek treatment early. [2] The Office of Minority Health states that among minorities, Hispanics have the highest uninsured rates in the nation contributing to their problem of accessing health care. Though heart disease rates have dropped during the last four years, obesity continues to be a major factor in the development of heart disease. [3] Because cardiovascular disease is the leading cause of death in the United States increasing awareness among my students and the community is vital.

Rationale

My school, Mt. Pleasant High, is a part of the large urban East Side Union High School District. Mt. Pleasant High School, located in San Jose California is comprised primarily by minority groups. By far our largest population is our Latino students comprising nearly 70% of our approximately 1800 student populations. Asian, Filipino, and East Indian comprise another 25% of our student body, with the remaining being our African American and Caucasian students. Our school has a close to 20% EL or re-designated EL learners, which lends itself to a need of trained teachers who are able to apply EL teaching strategies. Among the parents of our students, approximately 76% of them have never attended or graduated from college. Many of my students will pursue a college degree, but they will be the first in their families to attend college. The major teaching challenges of school continue to be literacy across all subjects and a low percentage of college-ready graduates. Similar to other urban schools, Mt. Pleasant High School students face the daily challenge of their socioeconomic status, which includes poverty. Many are faced with crime, pregnancy, and

turbulent lives at home, preventing them from focusing on their life as a student. [4]

Objective

The focus for my curriculum writing is to introduce my students to advances in medical technology in relation to hypertension. Study of the circulatory system will set the foundation for my unit. As a Physiology teacher, I seek to engage and immerse my students into my subject completely. It is my daily goal to keep my students excited about the course in order to not only raise their understanding but, in a larger sense, keep them motivated to pursue a higher education. Thus, a curriculum unit that will engage my students and connect real-life applications is important.

My intended audience for this curriculum unit is an 11th/ 12th grade Human Anatomy and Physiology course. Students opt to take this course after successful completion of Biology and Chemistry as a third or fourth year of science. Often students in this course are interested in college majors related to the health field, i.e. nursing, pediatrics, occupational therapy. Others are simply interested in the body and all its mechanics. The subject of Anatomy & Physiology is introduced during Biology, often at the end of the school year. Thus, this unit can be modified for beginning Biology. Further modifications can make this unit appropriate for middle school levels as well.

Our textbook is Hole's Anatomy and Physiology 8th edition. The textbook is outdated and the current edition available is the 12th edition. Thus, I often supplement the class with web-based resources and text, as well as different learning modalities. This is important because students often have a difficult time reading and understanding our textbook, since literacy continues to be a challenge for us school-wide. In Physiology, my students are exposed to the fundamentals of the human organ systems and their functions. Cardiovascular system physiology is taught within a three-week period wherein students are introduced to the anatomy of the heart and the vascular system. In addition, students learn the flow of blood through the pulmonary and systemic circuit. Because the focus of my unit is hypertension, students will learn the cardiac cycle, the relation between pressure, flow, and resistance, as well as the major regulators of blood pressure. With this background, students will be able to better understand hypertension, the different types of hypertension that exist, and current treatments. To connect their studies to a real world example, students will be introduced to an implantable device that helps to lower blood pressure. This example will also serve an introduction to their own investigation into new technologies that treat cardiovascular disorder.

Background

The Circulatory System

The Circulatory System consists of the heart and the arterial and venous system. In order to understand the organization it is necessary to discuss the anatomy of the heart and the anatomy of the arteries and veins. It is also important to trace the path of blood as it circulates through the body.

The Heart

The human heart is a four chambered pump. The pumping action of the heart is driven by the pacemaker (S-A node) which acts as a pulse generator that activates the muscles of the heart to contract. It is the changes in pressure within the chambers and the forceful contractions of cardiac muscle cells—collectively known as myocardium—that expels blood from the heart to the body. The heart includes two upper chambers called the atria and two lower larger chambers called the ventricles. The right and left ventricles are separated by a thick muscular wall called the interventricular septum. [5] The left atria and the left ventricle are separated by a valve, which opens in one direction to allow blood flow (from atrium to ventricle) but to prevent backflow. This valve is known as the bicuspid valve. Between the right atria and left ventricle is the tricuspid valve, which has a similar function. These valves open when pressure changes in the chambers and are aided by the chordae tendinae that are pulled by the contraction of the papillary muscles. Looking at the bisected heart macroscopically it is evident that the musculature of the left ventricle is far thicker than those surrounding the right ventricle and the atria above. [6] This is a key observation, since the left ventricle is the source of oxygenated blood that will be delivered to distance parts of the body, whereas the right ventricle sends blood to the lungs, which are nearby. The thickness of the muscular wall is related to the magnitude of the pressure that must be generated to drive blood through these different circuits.

Arteries and Veins

The arteries and veins differ in both structure and function. The arteries are subjected to the high blood pressures from the heart while the veins are not. Furthermore, the arteries function to deliver oxygen-rich blood to tissues of the body while veins function to return oxygen-poor blood to the heart. The aorta and pulmonary artery are two large arterial vessels stemming from the heart. In looking at the anatomy of the vessels further differences can be observed. The arteries and veins each have three major layers, the tunica interna, tunica media, and the tunica externa, however the veins have a thinner tunica media (a muscular layer) than the arterial vessels. [7] The reason for this difference is that arteries are subjected to high pressures against its walls, thus needing the resistance capability to withstand the stress of blood flow against its walls. Veins, on the other hand, are subjected to relatively low pressures. In addition, arteries need an ability to change their diameter, in order to regulate rates of blood delivery to the tissues that they serve. A thick muscular layer allows the arteries to control their diameter.

The veins have an added difference, in that many contain valves. These valves serve the purpose of preventing backflow of deoxygenated blood as it travels back to the heart. Like arteries, veins vary in size depending on the volume of blood they handle and location in the body. In general veins are larger in diameter than arteries increasing their capacity for blood storage. In this way, veins can serve as a blood reservoir. The superior vena cava and inferior vena cava are two of the largest veins entering the heart bringing de-oxygenated blood. [8]

Blood

Blood is an organ comprised of various elements. Its composition is 55% plasma and 45% hematocrit or formed elements. The major elements include red blood cells (erythrocytes), white blood cells (leukocytes), and platelets, which are suspended in a matrix called plasma. [9] Red blood cells are biconcave discs increasing their ability to take up oxygen and bind hemoglobin. As red cells move through the arteries and veins they have the ability to fold or inflate. White blood cells are classified into granulocytes and agranulocytes depending on the presence of granules in the cytoplasm. Unlike red blood cells, the main purpose of white

blood cells is defense; they respond to injury and the presence of foreign cells. Plasma is the fluid which all formed elements of blood travel through. Because plasma is 91% water it's a low viscosity fluid making it ideal for the formed elements to travel through. [10]

Blood Flow

Systemic Circuit

The circulatory system serves as the highways for blood to travel through. It can be divided into major highways of functional blood flow - the systemic circuit and pulmonary circuit. The systemic circuit includes the heart, arteries, capillaries, and veins that deliver oxygenated blood to the tissues of the body. (Fig. 1 [11]) The path of blood can be traced in a circular pattern beginning at any point in the body. Beginning in the left ventricle of the heart blood passes through the aortic valve, through the aorta, and into the systemic circulation. The large arteries bifurcate into smaller arteries. As the arteries become smaller in diameter they become arterioles which lead to capillary beds - the site of oxygen / carbon dioxide exchange. As oxygen diffuses into the tissues, carbon dioxide begins its path to the lungs for expulsion and de-oxygenated red blood cells return to the heart for re-oxygenation. Capillary beds lead to small venules and larger veins, ending with the superior and inferior vena cava. De-oxygenated blood is dumped into right atrium and passes through the tricuspid valve into the right ventricle. [12]

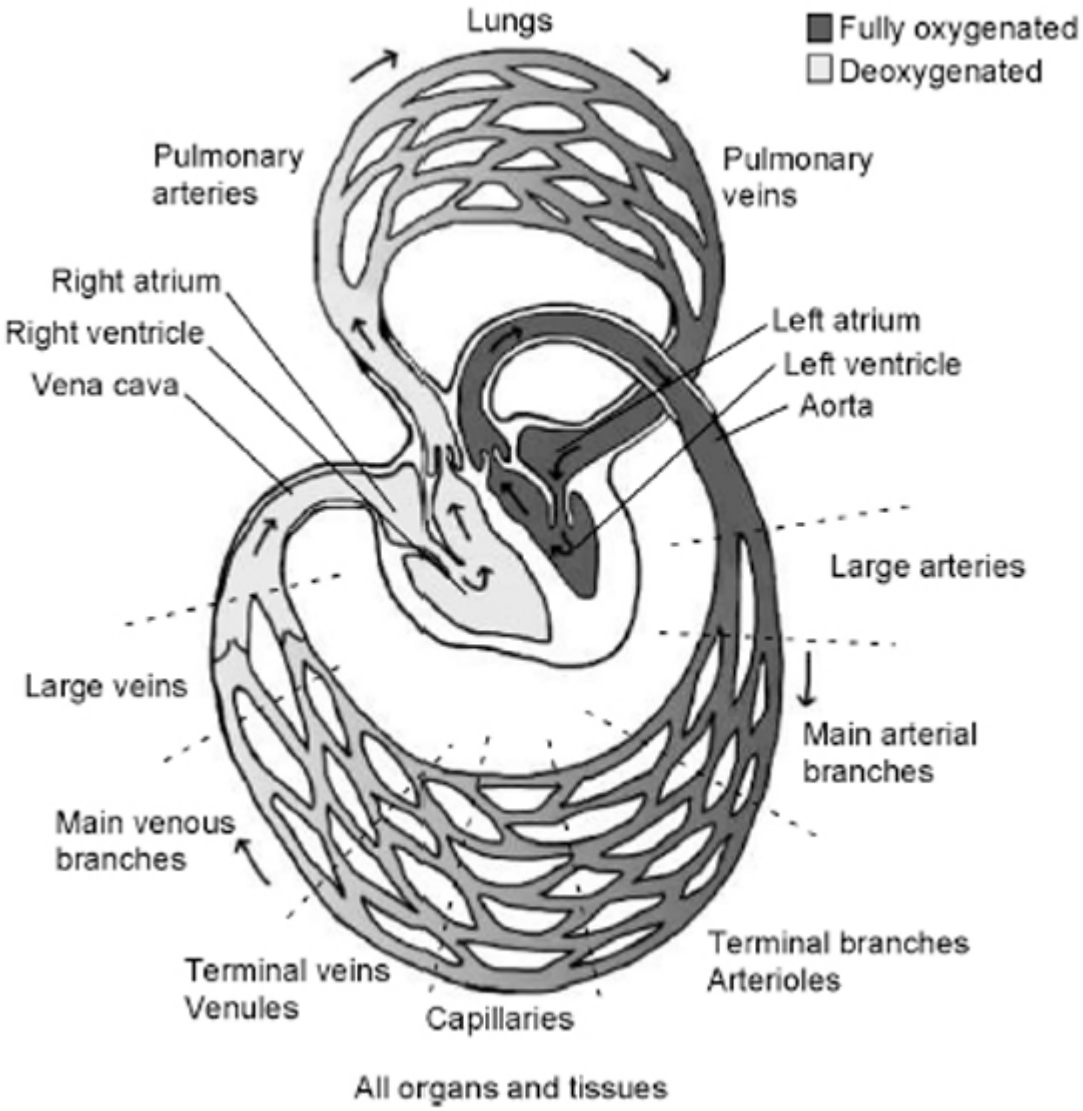

Fig. 1. The path of blood through the circulatory system. Image reproduced from Saltzman (2009) with permission.

Pulmonary Circuit

The pulmonary circuit of blood flow includes the heart and the lungs. Its major function is to deliver de-oxygenated blood to the alveoli, deep in the lungs, and to return oxygenated blood to the left side of the heart. Blood from the systemic circuit leaves the right atrium through the pulmonary valve and pulmonary artery. Once carbon dioxide/oxygen exchange is achieved, pulmonary veins return oxygenated blood to the left atrium of the heart. At this point oxygen rich blood is ready again to enter the left ventricle through the biscuspid valve for systemic circulation.

Blood Pressure and Hypertension

In surveying my students, many are familiar with the idea of blood pressure but are not aware of the multiple health implications of untreated hypertension. Furthermore, though the term "pressure" is understood, they do not understand where the pressure exists or what it is pressing against. I plan to delve deeper into the topic of hypertension, with a focus on minority populations, so that the subject becomes more relevant to my

students' lives. Over the course of the unit it is my hope that students will gain a fuller understanding of the circulatory system and how "the silent-killer" known as hypertension can affect on the human body if left untreated.

Pressure & the Cardiac Cycle

The idea of pressure seems easy enough to understand if one were asked to apply pressure on a wound. The word implies a force and pressure is a measure of force against a specific surface area. Atmospheric pressure is the amount of force per unit area exerted against a surface by the weight of air above that surface in the Earth's atmosphere. In order to measure pressure, we use manometers with fluids inside like mercury (Hg), since we know the mass of mercury, we can track the amount of mercury displaced as a measurement of pressure. Thus, mm Hg, means the amount of force exerted to move mercury x amount of Hg some mm. When the force (i.e. pushing) is increased then the pressure against the specific surface area also increases. Pressure is measured in mm Hg because at sea level, the atmosphere or air around us can support a 760-mm column of mercury inside a glass tube called a barometer. The pressure (P) exerted by a column of liquid of height h and density P is given by the hydrostatic pressure equation: P = *Pgh.* In measuring blood we use as device called a sphygmomanometer, which is a type of manometer used with an inflatable arm cuff to measure blood pressure. When taking one's blood measure we are measuring the amount of pressure required to block circulation to the artery and then the amount of pressure that blood within the vessels exerts against the pressure from the cuff. Thus, the systolic and diastolic pressure are in units of mm Hg.

The Cardiac Cycle

Though students have often heard of the words systolic and diastolic pressure, they often cannot relate it to the actual events in the cardiac cycle nor are they aware of the mechanics of a blood measure monitor.

In the cardiac cycle, pressure and blood volume can be tracked in order to understand how blood pressure and myocardial contraction/relaxation are related. Pressure gradients (differences in pressure between different locations) and strength of myocardial contraction drive the flow of blood. Atrial contraction pushes blood into the ventricles because the pressure in the atria is higher forcing the tricuspid and bicuspid valves to open, allowing the ventricles to fill. The increase in pressure of the atria is due to the pressure exerted by blood as it fills the atria. The time during which the atria contract is called atrial systole. As the ventricles fill, pressure changes and volume changes, the atrioventricular valves (tricuspid and bicuspid valves) close at the point in which ventricular pressure is higher than atrial pressure. As the ventricles continue to contract (ventricular systole), the increasing pressure on the blood volume forces a ventricular ejection. Blood from the left ventricle is expelled into the aorta when the aortic valves open, while blood in the right ventricle is expelled into the pulmonary artery when the pulmonary valves open. At this point aortic pressure is lower than ventricular pressure thus allowing the expulsion of blood from the ventricles. Because of the change in blood volume in the ventricles, the pressure changes once again causing the aortic and pulmonary valve to close and the ventricles to relax marking the beginning of ventricular diastole. Soon the atria will once again fill beginning the cycle once again. [13]

When blood pressure is measured using a blood pressure monitor, it is the force that blood exerts against a point in the arteries that is measured. If a sphygmomanometer is used, it is used in conjunction with a stethoscope. The cuff is used to apply pressure around the arm, blocking blood flow in the brachial artery. As the pressure is slowly released the sound of blood rushing through the occluded point is measured: this is the systolic pressure that is first recorded. When the sound of blood movement is no longer heard, the pressure is

recorded as diastolic pressure. [14]

Regulation of Blood Pressure

Normal blood pressure is 120 mm Hg/ 80 mm Hg (systolic/diastolic). Though this mean arterial blood pressure is commonly known in adults, what is not commonly known is that pressure varies throughout the whole circulatory system. Because of these changes, pressure drops create a means through which blood can circulate. However, how fast or slow blood circulates is not only determined by the amount of pressure drops in the arteries and veins. Recalling that blood pressure is the force against the arterial walls, it is subjected to various factors that change the initial force. Such factors include viscosity of blood, the peripheral resistance of arteries, and the distance from the original source of the force. Changes to the viscosity of blood and the resistance of the arteries will cause an imbalance in the mean arterial pressure. Because the body likes to maintain a homeostatic balance, neural reflexes in conjunction with negative feedback loops take action to maintain the mean arterial pressure.

Neural Reflexes

The human body regulates itself through a series of mechanisms called negative feedback loops. A feedback loop includes a sensor or detector to a stimulus, a control center which makes decisions as to how to respond to the stimulus, and an effector which sends a resulting response to the stimulus. A simple example is the response the body would have to changes in temperature. If sensors within the skin detect a drop in temperature, they will send signals to the brain to send the appropriate response to the muscles in the skin to contract. One effect of the stimulus is the contraction of arrector pili muscle to raise the hair on your skin causing goose bumps. Another is to stimulate skeletal muscles to contract (shiver) causing you to generate heat, which is a byproduct of skeletal muscle contraction. [15] In a similar fashion negative feedback loops regulate arterial blood pressure. This reflex involves a detector, afferent neural pathway, coordinating center in the brain, efferent neural pathway, and effectors. Primary receptors include baroreceptors which are stretch receptors in the vascular walls and secondary receptors include chemoreceptors in blood. The medulla is the coordinating center which makes the decision as to how to respond to the detectors. The effectors are the heart pacemaker (the SA node), cardiac muscle, vascular smooth muscle, and adrenal medulla that ultimately carry out the action in the organ. [16]

Baroreceptor control of arterial pressure is a type of feedback loop that includes a detector (baroreceptor), an afferent neural pathway, a control center (medulla), and an efferent neural pathway that activates the effectors (heart and blood vessels). Baroreceptors are located in high pressures areas of the carotid sinus and aortic arch. [17] Because baroreceptors are stretch receptors they do not really respond to high pressure within arteries, they are instead responding to the stretching of the arterial wall due to high pressure or increased intravascular volume. The more the arterial wall stretches, the more the afferent neurons fire nerve impulses to the medulla. The medullary cardiovascular center is responsible for deciding which type of response is appropriate. The response will either be acceleratory or inhibitory. If the response is to accelerate heart rate then sympathetic nerve fibers will be fired. The result will be an increase in heart rate. If the response is to inhibit or to slow heart rate and thereby decrease pressure, parasympathetic efferent fibers will fire. The result of parasympathetic nerves firing is decreased heart rate, reduction in cardiac contraction, and vasodilatation, thus reducing mean arterial blood pressure. [18]

Peripheral Resistance

Besides neural reflexes, peripheral resistance is a factor that affects blood flow. Resistance depends on the thickness of the fluid (viscosity) and the structure of the vessels through which it flows. (Fig. 2) It is the frictional force of blood against the walls of the blood vessels. Thus when there is more resistance, the heart will have to pump harder to overcome that force. Blood viscosity is the ease with which blood flows through the vessels. Thus the more viscous blood is blood pressure rises since the heart will have to work harder to move that same volume of blood with its increased blood cells and blood proteins. [19]

Fig. 2 Resistance Equation [20]

$$R = \frac{8\mu L}{\pi r^4_v}$$

R = Resistance of a cylinder
L = Length
μ = viscosity of a liquid
R = radius of the cylinder

In addition, peripheral resistance is yet another factor that alters flow. At a given pressure gradient, peripheral resistance decreases blood flow: when the flow must be maintained constant, an increased resistant requires an increase in blood pressure. However, peripheral resistance can be overcome by changing the diameter of the blood vessel. Vasodilation decreases resistance by increasing the diameter through which blood can flow through a certain point. Vasoconstriction has the opposite affect which increases resistance by decreasing the diameter through which blood can flow. The vasomotor center of the brain is responsible for controlling the muscle of arterioles. Sending sympathetic impulses causes vasoconstriction and thus an increase in peripheral resistance and blood pressure. While decreasing the sympathetic impulses has the opposite effect. [21]

Hypertension

Hypertension is the state at which arterial blood pressure is consistently elevated above the normal pressure of 120 mmHg over 80 mmHg. A person who is hypertensive would have a systolic pressure greater than 139 mmHg and a diastolic pressure greater than 89 mmHg.

There are various stages of hypertension: Prehypertension, Stage 1, and Stage 2. Pre-hypertension describe a slight rise in normal or ideal pressure. The systolic rate would have to between 120 and 139 mmHg, while the diastolic would be between 80 to 89 mmHg. Stage 1 Hypertension would be a systolic rate above 140 mmHg and 80 mmHg for the diastolic rate. Stage 2 hypertension is indicated by a blood pressure or 160/100 mmHg. In addition there are different types of hypertension: primary hypertension and resistant hypertension. Primary hypertension usually develops as one ages. Resistant hypertension may be due failure of someone with hypertension to ignore their condition or they have become resistant to prescriptions for lowering blood pressure. [22]

Treatments

Treatments for people with hypertension vary from simple changes of diet and exercise, to pills, to implantable devices. The prescribed medical treatments available for patients who are hypertensive include

various medications including diuretics (or water pills), beta blockers, calcium channel blockers, angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, and direct vasodilators. If the hypertension is resistant to medications, implantable baroreflex hypertension systems like Rheos System are available. This implantable device is designed to regulate pressure sensors in the brain and thereby trigger effectors in the body that effectively lower blood pressure.

The use of baroreflex stimulation began as early as the 1950s in hypertensive dogs. Later applications by Carlsen and colleagues led to successful results in reducing hypertension in a 40 year old man with long-standing history of hypertension and regular use of four anti-hypertensive drugs. With treatment, his BP fell from a 250/195 to 150/90 mm Hg. Implantable devices were slow to develop due to limitations in technology, thus clinical use of activating baroreceptors to reduce blood pressure was impeded. [23]

Currently the Rheos Hypertension System® by CVRx is in clinical trials, and it shows great promise in reducing mean arterial blood pressure. The baroreflex hypertension therapy includes three components an Implantable Pulse Generator, Carotid Sinus Leads, and external Programmer System. The small cell phone sized pulse generator is surgically implanted beneath the collar bone and under the skin. The carotid sinus leads are attached to the carotid arteries on both sides of the neck. Finally, the programmer system is external so the frequencies of the pulses that stimulate the baroreflex are adjusted specifically for each patient. [24] Clinical studies reported in *Current Hypertension* have shown great promise for the Rheos system, showing marked decreases in resistant hypertensive patients. After 3 years, under BHT therapy, patients have shown up to a 30 mm Hg drop in systolic pressure for those having a systolic pressure of 190 mm Hg. While diastolic pressures have been shown to drop 22 mm Hg for those with diastolic pressure of 112 mm Hg. [25] Besides the reduction in blood pressure, Bisognano and Kaufman have shown an improved cardiac structure with baroreflex activation therapy. Using the Rheos system they report improved ventricular function and size. [26] Because of the success of the Rheos System, its use may eventually expand to a heart failure treatment.

Another technological advancement that may help patients who have irreparably damaged blood vessels is tissue-engineered vascular grafts. [27] Dr. Laura Niklason and her groups of research scientists have developed a technique that allows vascular tissues to be grown in laboratory bioreactors. Their process involves using donor smooth muscle cells that are grown on polyglycolic acid (PGA) scaffolds shaped like a vessel. Within a bioreactor containing media that allows for optimal tissue growth, the smooth cells proliferate and invade the PGA scaffold. Over a period of time, enough cells accumulate on the scaffold that assumes the shape of the vascular tube. When the PGA degrades and is dissolves away, the remaining tissue is a vascular graft. [28] Thus far, the tissue is used as a dialysis graft, showing great potential because of its durability and lack of immunological rejection. This technology is especially interesting for hypertensive patients since the engineered vascular graft is able to resist high pressures up to 2150 mmHg whereas native tissues can withstand pressures up to 1680 mm Hg. [29] Tissue engineered arteries may soon be able to replace atherosclerotic vessels in addition to its current use as a dialysis graft.

Cardiovascular Disease

Because high blood pressure and hypertension can lead to serious cardiovascular disease, it is important to introduce the concept. Cardiovascular disease (CVD) can include any disease that can affect your heart and the blood vessels. Included is a long list of heart related disorders like arrhythmias, coronary artery disease, heart infections, and congenital heart defects. A person with arrhythmias may experience symptoms of tachycardia (fast heartbeat), bradycardia (slow heartbeat), chest pain, dizziness, and shortness of breath.

People with heart defects may have blue skin due to lack of oxygen circulating, shortness of breath, and swelling in the extremities. Another form of CVD called cardiomyopathy causes sensations of fatigue, breathlessness, irregular heartbeat, and swelling due to the thickening or stiffening of the cardiac muscle. Problems with the valves of the heart include symptoms of chest pain, shortness of breath, heart murmurs, and fainting. All of the above are examples of cardiovascular disease. [30]

Coronary Artery Disease

Coronary Artery Disease (CAD) is the gradual blockage of the coronary arteries of the heart due to atherosclerosis. As plaque builds up within the small arteries, the lumen begins to narrow and flow of blood eventually slows or stops. People with CAD may experience angina (chest pain), breathlessness, fatigue, and weakness. Often patients with CAD are on blood pressure medications to lower their blood pressure. Some may take nitroglycerin pills to decrease chest pain. [31]

Strategies

During the course of this unit, I will use PowerPoint presentations, web-based videos and animations, science-based articles, dissection labs, and supplemental text to engage my students into the unit. My hour with my students is structured to include an opening or Do-first task, 15-20 minute lecture, individual or group activity, and Do-Last. With the exception of lab days and work days, my students become familiar with this structure within the first two to three weeks of the semester. This is imperative because my students often lack structure in their daily lives. By providing a familiar environment and daily structure, students are not left wondering, "What are we doing today?"

Initially, in a curriculum unit, I begin with an engagement activity. This may be an article, a demonstration, a picture, a short video, or simply a question. Once engaged, I ask students to make the connection to the unit we are about to study. For this unit, I will ask three students to volunteer to have their blood pressure taken. I will use my blood pressure as a comparison, and have my students discuss what they think they know about the numbers from the demonstration. From their answers, I will be able to evaluate their prior knowledge concerning high blood pressure and cardiovascular disease.

Strategies throughout the course of the unit will include:

- Using models of the heart to show its anatomy

- Comparing x-rays of healthy hearts and hearts with CVD

- Having students read CVD, hypertension articles to increase their cross-curricular literacy skills

- Discussions that will engage their critical thinking skills, especially in relation to clinical focus readings

- Modeling pressure using different size tubes, volumes, and forces to mimic the blood vessels

- Exploration into technologies that treat hypertension, coronary artery disease, and CVD

- Videos of surgeries to show real-life applications.

Classroom Activities

Lesson One

Objective

To teach the flow of blood through the circulatory system.

Materials

Textbook, cards, envelope or baggie

Standard

CA State Science Standards: 1a, 1d, 1m, 9 (Appendix 1)

Introduction

To teach my students blood flow through the circulatory system, I will use sets of cards and arrows with all the major structures of the heart, arterial system, and venous system. The cards and arrows will be color coded, to stress whether blood flowing through that structure is oxygenated or deoxygenated. By doing so, students can participate in a hands on activity to help their memorization skill. This teaching tool can easily applied to the memorization of any other mechanism in physiology, for example, the memorization of blood clotting cascade.

Procedure

Before lecturing to my students the pathway of blood through the circulatory system, students will participate in a circulatory puzzle activity. Before class, I will have prepared a class set of bagged or enveloped structures including arrows for students to use in class (Fig. 3). Students will be prompted to clear their desks to maximize the work space. Because many students come with some idea of how blood flows through the circulatory system, I will first prompt them to try to put all the structures inside the envelope into order including all the arrows representing oxygenated and deoxygenated blood.

Fig 3. Structures for Circulatory Pathway (to be copied and made into cards for Lesson 1)

Left Ventricle	Left Atrium	Bicuspid Valve	Aortic Valve	Aorta
→	→	→	→	→
Right Ventricle	Right Atrium	Tricuspid Valve	Pulmonary Valve	Pulmonary Artery
→	→	→	→	→
Lungs	Capillary Bed	Venules	Veins	Arterioles
→	→	→	→	→
Arteries	Superior Vena Cava/Inferior Vena Cava	Pulmonary Veins		
→	→	→		

Students will be given a five minute time frame to do this. During the five minutes, students will not be allowed to use textbooks or ask questions from their peers or teacher to put together the pieces. In this manner, I will be assessing their thinking strategies, their ability to group structures, and formulate a plan as to how the path flows. After the five minutes, I will ask questions, "Why was it difficult to put together? Why did you group certain structures that way? Why didn't you group others? What do you think the blue arrows mean? What do the red arrows represent? Why did you place one structure above the other?" Once I've discussed the first activity, then I will teach students the actual flow of blood in sections (the left side of the heart, the arterial system, the venous system, the right side of the heart and lung).

Initially, I will begin with the left side of the heart (left atrium, bicuspid valve, left ventricle, aortic valve, aorta) having my students place red each structure. Then I will have my students add on the arterial system (arteries, arterioles) and the capillary bed. Students will then have to decide which arrows they will use, red or blue. Once I've assessed their understanding by a simply walking around to each desk, I will have my students add the venules, veins, superior vena cava/inferior vena cava. Since, I do want my students to understand that oxygenated blood and deoxygenated blood also travel to the lungs, the pulmonary arteries and veins will also be added to the puzzle. For simplicity, I will not include the alveolus.

When students have completed the puzzle, I will prompt them to remove just the arterial and venous structures, mix the pieces, and then replace them. Students should repeat this until they are able to easily place those structures in order. I will repeat this strategy with the other structures of the heart, having students remove, mix, and replace structures until they are able to complete the circulatory path with the aid of any structures as a starting point.

At the end of the activity, I will repeat the questions from the beginning of class, this time students will have to answer the questions into their notebook or binder paper. This will serve as a closure for the day's activity

and thus reinforcing their understanding.

Lesson Duration

One class period

Assessment

Informal assessment and responses to questions will be utilized as an assessment.

Lesson Two

Objective

To introduce Hypertension and Cardiovascular Disease

Materials

Articles from the Centers for Disease Control, American Heart Association, American Stroke Association

Standards

CA State Science Standards: 1a, 1d, 1m, 9 (Appendix 1)

Introduction

In order to prepare students for the rigor of the Gallery Walk, students will take part in short expert panel discussions. This will introduce them to web-researching, speech presentation, and Q & A session. In participating in this panel, students will have a chance to begin thinking about their larger research project while applying the lecture material from class.

Lesson Duration

3 class periods (3 hours), 2 periods to prep, 1 period for panels.

List of diseases to be chosen:

- High Blood Pressure & Hypertension,

- Arrhythmia

- Atherosclerosis

- Peripheral Artery Disease

- Coronary Artery Disease

- Deep Vein Thrombosis

- Heart Attack

- Congestive Heart Failure

- Heart Valve Problems

- Angina

- Stroke

Pre-Panel Preparation

Students will be grouped into groups (4 – 5 students). The group will serve as the expert panel for their one disease. Students will be assigned to do readings based on their CVD topics using various websites. (See Resources for Students) Students will be given one class period to prepare their material for the panel discussions. All students will participate in formulating questions for the panel and the Q&A session. Students will turn in a copy of their prepared one-minute speech based on their specific expertise (epidemiology, pathophysiology, symptoms, diagnosis, and treatment). All students will take notes on the list of questions that could be asked during the panel discussions.

Panel Discussion:

All students will be instructed to take notes on each of the expert panels and to participate. I will assess student participation throughout the panel discussions based on their preparedness, mastery of the topic, and accuracy of the information presented.

Each panel will last 10 minutes. During panel discussion, each expert will introduce themselves, state their expertise, and introduce the next expert in their team. After, the experts have spoken the 5 minute Q & A session will begin. Student audience members must be responsible for asking questions throughout the five minute period. When the session ends the leaving panel will introduce the next group of experts.

Informal assessment

Teacher will assess student participation throughout the panel discussions.

Formal assessment

Students will be quizzed on each of the panel discussions based on the notes & questions from the discussions.

Lesson Three

Midway through our unit, students will be asked to research a cardiovascular disease at length (See Resources for Teachers). Having presented material on hypertension and having participated in the brief panel discussions my students will have some idea of the dangers of untreated hypertension and subsequent disease that stem from it. Students will be asked pair-up. Each pair will have to choose a CVD and find a technology used to treat that specific CVD. Students will be given time during class to do web- based research, create presentations and a model of their heart or technology. During a two day Gallery Walk students will have the chance to present to their peers what they've learned. This is the chance for students to invite other teachers, administration, and parents to view what they've accomplished and to share their knowledge. As students groups are viewing and listening to presentations, students will be using rubrics to

assess the project so that students have a voice in the assessment process. (See Resources for Teachers)

The Gallery Walk is the culmination of the cardiovascular unit. Students presentations will be videotaped, assessed, and shared with others. As a closure, students will be asked to answer a quick survey to see what they've learned and to see the value of the unit and the activities included.

Resources

Resources for Students

Lesson Plan Two - Student Articles for Panel Discussion:

Students can be directed to the follow websites for articles for their panel discussions:

Centers for Disease Control

- http://www.cde.ca.gov/

Medscape

- http://emedicine.medscape.com/article/162449-overview#aw2aab6b7

American Heart Association

- http://www.heart.org/HEARTORG/

American Stroke Associations

- http://www.strokeassociation.org/STROKEORG/

List of diseases and articles for student readings:

High Blood Pressure & Hypertension,

http://www.cdc.gov/bloodpressure/

http://emedicine.medscape.com/article/162449-overview#aw2aab6b7

Arrhythmia

http://www.heart.org/HEARTORG/Conditions/Arrhythmia/Arrhythmia_UCM_002013_SubHomePage.jsp

Atherosclerosis

http://www.heart.org/HEARTORG/Conditions/Cholesterol/WhyCholesterolMatters/Atherosclerosis_UCM_305564_Article.jsp

Peripheral Artery Disease

http://www.cdc.gov/DHDSP/data_statistics/fact_sheets/fs_PAD.htm

Coronary Artery Disease

http://www.cdc.gov/heartdisease/coronary_ad.htm

Deep Vein Thrombosis

http://wwwnc.cdc.gov/travel/yellowbook/2012/chapter-2-the-pre-travel-consultation/deep-vein-thrombosis-and-pulmonary-embolism.htm

Heart Attack

http://www.cdc.gov/heartdisease/heart_attack.htm

Congestive Heart Failure

http://www.heart.org/HEARTORG/Conditions/CongenitalHeartDefects/TheImpactofCongenitalHeartDefects/Congestive-Heart-Failure_UCM_307111_Article.jsp

Heart Valve Problems

http://www.heart.org/HEARTORG/Caregiver/Resources/WhatisCardiovascularDisease/What-is-Cardiovascular-Disease_UCM_301852_Article.jsp

Angina

http://www.heart.org/idc/groups/heart-public/wcm/hcm/documents/downloadable/ucm_300287.pdf

Stroke

http://www.strokeassociation.org/STROKEORG/AboutStroke/About-Stroke_UCM_308529_SubHomePage.jsp

Resources for Teachers

Lesson Plan Three - Student hand-out for Cardiovascular Disease Project

You've just been hired by the Public Health Office (PHO) at your college. Your director informs you that the office will be hosting a public forum to increase cardiovascular disease awareness at your college. During the day long forum, visitors on campus, teachers, and students will be moving from table to table to gain knowledge on various cardiovascular diseases and current treatments. It is the responsibility of everyone in the PHO to research a disease, create a presentation with a model to support the presentation, and to inform the public during the forum.

Requirements:

1. Detailed outline of research paper & presentation layout

2. 3 page research paper

3. Completed, edited presentation (Power Point, academic poster, prezi, or glogster)

4. Model/3D visual

5. Evaluation & Survey

Research Paper:

- 3 pages, typed, Times New Roman, 12 size font, 1 inch margins

- APA format

- Introduction, Description, Anatomy & Physiology Connection, Symptoms, Treatments, Technological Advancement Applied

- Works Cited in APA

- Cover Page and Works Cited are not included in the 3 page requirement.

- Cover Page includes (Title, Names, Date, Period, Subject)

Point Value (200 points)

Point Breakdown

1. Outline – 10 points

2. Research Paper – 100 points

3. Poster/Power Point/Prezi/Glogster – 50 points

4. Presentation – 20 points

5. Model – 20 points

6. Evaluation/Survey – 10 points

Lesson Plan Three - Gallery Walk Rubric

	Exemplary	Satisfactory	Needs Improvement
Poster	The poster includes a concise introduction to a CVD, the physiological concepts, and explanation of technological advancements. The poster is creative, clear and concise. 30 points	The poster includes a concise introduction to a CVD, the physiological concepts, and explanation of technological advancements. The poster lacks creativity and contains multiple grammatical errors. 20 points	The poster lacks more than one of the requirements of a satisfactory poster. 10 points
Quality of Information	The information is accurate, well researched, and shows depth in understanding. 20 points	Some information seems poorly researched and explained. 15 points	Very little research is evident, information presented shows gross misunderstandings of the circulatory system. 10 points
Model/ Visual	The model/visual heightens the overall affectivity of the poster. It is neat, creative, and correlates well with the topic. 20 points	The model/visual is present, but does little to heighten the overall affectivity of the poster. It is neat and creative. 15 points	The model/visual is present, but doe not relate to the topic. It is evident that it is hastily done. 10 points
Presentation Skills	The team together able to explain their topic in a Gallery Walk expertly. 20 points	The team together able to explain their topic in a Gallery Walk with some aide from notes and poster. 15 points	The Team is unable to explain their topic in a Gallery Walk coherently. Lack of preparation is evident. 10 points

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Notes

1. 1 Hypertension – The Silent Killer
2. 2 Hypertension Related Mortality
3. 3 Hispanic and Latino Profile

4. 4 ESUHSD Fact Sheet
5. 5 Hole's Anatomy Physiology, The Circulatory System
6. 6 Ibid
7. 7 Ibid
8. 8 Biomedical Engineering
9. 9 Clinical Hypertension
10. 10 Physiology Coloring Book
11. 11 e-how image
12. 12 Hole's Anatomy Physiology, The Circulatory System
13. 13 Physiology Coloring Book
14. 14 Ibid
15. 15 Hole's Anatomy Physiology, The Circulatory System
16. 16 Medical Physiology, 535
17. 17 Ibid, 536-540
18. 18 Baroreflex Stimulation
19. 19 Physiology Coloring Book
20. 20 Biomedical Engineering
21. 21 Medical Physiology
22. 22 CDC, Ibid
23. 23 Baroreflex Stimulation
24. 24 CVRx
25. 25 Baroreflex Stimulation
26. 26 Bisognano
27. 27 Niklason – Functional arteries grown in vitro
28. 28 Ibid
29. 29 Ibid
30. 30 Coronary artery disease
31. 31 Pubmed Health

Appendix

CA State Science Standards

Physiology

9. Organ systems work in a coordinated fashion to maintain a homeostatic balance.

a. Students know how the complementary activity of major body systems provides

c. Students know how feedback mechanisms

Scientific Investigation

1. Scientific progress is made by asking meaningful questions as a basis for understanding concepts.

a. Students will select and use appropriate tools and technology

d. Students will formulate explanations by using logic and evidence.

l. Students will Analyze situations and solve problems that require combining and applying concepts from more than one area of science.

m. Students will Investigate a science-based societal issue by researching the literature, analyzing data, and communicating the findings.