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Geo-Aerospace Blood Circulation in Humans

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Abstract

Blood circulatory system is a system that includes heart, blood vessels and blood which is circulated throughout the body. The blood circulation in humans is the process where blood is circulated throughout the body in closed circuits. Blood circulation on land is normal unless sudden position change from sleep to stand and prolonged standing. When a body freely falls in standing position in air towards earth, it experiences –G effect as more blood tends to move towards head. When a body accelerates upwards it experiences +G effect as blood accumulates in legs. A fighter pilot's G-suit also called 'anti-G suit' is one-piece jumpsuit that protects pilot from feeling discomfort and losing consciousness from pressure of G-forces bearing down on pilot. When a person is in microgravity their blood circulation changes drastically. It can cause muscular atrophy, blood pressure lowering etc. What we learn about physiological changes on space has important applications on ground as well, in part because many of the changes seen in space resemble those caused by aging on earth. Important research is being done on the space station to learn more about SANS [Spaceflight Associated Neuro-Ocular Syndrome] and to develop and test counter measures to many possible different cardiovascular changes.

Keywords*: Blood Circulation, +G effect, -G effect, G-Suit, Microgravity, SANS.*

1. Introduction

Blood is the fluid connective tissue that plays major role in transportation of nutrients and metabolic products. Blood circulation is process where blood circulates throughout body in order to meet needs of cells in our body. In human's, blood circulation is of closed type where it circulates in 2 circuits; Pulmonary circuit and Systemic circuit. Gravitational force of earth affects the activity of cardiovascular system in human being. [2] [3] [6] [9]

1.1 Blood Circulation

The blood circulation in humans is the process where blood is circulated throughout the body in closed circuits. It occurs through the help of the cardiovascular system. It helps to deliver oxygen, nutrients, hormones and other important substances to cells and organs in body and to withdraw carbon dioxide and waste products from cells. [2] [7] [8]

1.2 Components of Blood Circulation

Components of Blood Circulation includes Heart, Blood vessels, Blood.

1.2.1 Heart

The heart is a muscular pump in thoracic cavity. It is often referred to as the workhouse of the cardiovascular system. Each day, heart beats approximately 100000 times. However, heart doesn't beat at a steady rate. It can adjust its rate to meet the changing needs of the body for example during exercise, heartbeat rate is faster. It is same as the size of the fist of an individual. An average adult's heart is generally about 14 centimeters long and 9 centimeters wide. Heart is located between the right and left lungs in the middle of your chest. It is slightly behind and to the left of the sternum. Duration of one cardiac cycle is 0.8 seconds. Heart normally beats 70-75 times per min (average 72 beats/min). Cardiac output can be defined as volume of blood pumped out by each ventricle per minute and averages 5000ml or 5 liters in a healthy individual. During a cardiac cycle, each ventricle pumps out approximately 70 ml of blood which is called "stroke volume". Cardiac output is stroke

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volume multiplied by heart rate (no. of beats min-1). Our body has ability to alter stroke volume and heart rate and thereby cardiac output. [2] [7] [10]

1.2.2 Blood Vessels

There are three main types of blood vessels

Arteries: Arteries are thin muscular tubes that carry oxygenated bold away from heart and to every part of your body. It starts at heart and travels up to chest (ascending aorta) and then down into stomach (descending aorta).

Veins: These blood vessels return oxygen-depleted blood to heart veins start small (venules) and get larger as they approach the heart. Two central veins deliver blood to your heart. Superior vena cava carries blood from upper body (head and arms) and Inferior vena cava carries blood from lower parts of body (legs) to heart. Veins in legs have valves to keep blood from flowing backward.

Capillaries: These blood vessels connect very small arteries (arterioles) and veins (venules). Capillaries have thin walls that allow oxygen, carbon dioxide, nutrients and waste products to pass into and out of cells. [2] [8]

1.2.3 Blood

Blood is fluid connective tissue. That travels through the body. It takes oxygen and nutrients to every cell of body and carries away waste from cells. Blood is made up of plasma (55%) and formed elements (45%). Plasma consists of water (90-92%), proteins (6-8%), minerals (small amounts), Clotting factors, glucose, amino acids and lipids. Formed elements are broadly classified into erythrocytes or red blood cells (4.1 – 5.9 million cells/mcL) leucocytes or white blood cells (4,500-11,000 cells/mcL) and Thrombocytes or platelets (150,000-450,000 platelets/mcL). [12]

Organization: Basic information on Blood Circulation is given in introduction. Process of Blood circulation is explained in Section 2. In Section 3, Blood Circulation on Land is explained. Blood Circulation in Air is explained in Section 4. Blood Circulation in Space is explained in Section 5. Research Analysis is explained in Section 6. Acknowledgment is written in Section 7. Conclusion is given in Section 8, followed by References in Section 9.

2. Process of Blood Circulation

Our blood circulatory system has 2 circuits shown in Figure 1 Blood circulates through these circuits in continuous pattern.

2.1 Pulmonary Circuit

This circuit carries blood without oxygen from heart to lungs. The blood pumped by right ventricle enters pulmonary artery, whereas left ventricle pumps blood into aorta. Deoxygenated blood pumped into pulmonary artery is passed on to lungs where purification of this blood that occurs by simple diffusion across alveolar membrane (which is highly vascularized) of lungs takes place. From here, oxygenated blood (after purification) is carried by pulmonary veins into left atrium of heart. [2] [7] [8]

2.2 Systemic Circuit

This circuit carries blood with oxygen from heart to all parts of body.

The oxygenated blood entering aorta is carried by a network of arteries, arterioles and capillaries to all the cells of our body from where deoxygenated blood is collected (Oxygen is diffused into the cells from arteries, arterioles and capillaries and carbon dioxide in cells diffuses into bloodstream) by venules and veins and eventually into vena cava. The deoxygenated blood from vena cava is emptied into right atrium. Systemic circulation provides nutrients, oxygen and other essential substances to tissues and takes away carbon dioxide and other harmful substances for elimination. [2] [7] [8]

3. Blood Circulation on Land (Geo)

Gravitational forces of earth considerably have an effect on venous return and cardiac output of a person. To demonstrate this, consider someone who is laying down (supine position) and stands up all of a sudden. While he is lying down, gravitational forces act similarly on thorax, abdomen and legs due to the fact that they lie in equal horizontal plane and blood is evenly distributed in body. While the person abruptly stands upright from sleep, gravity acts on the vascular volume making blood to build up in lower parts of the body. Larger quantity of blood shift takes place in veins. Veins readily expand with blood. Consequently, venous volume

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and pressure end up being very excessive in the feet and lower limbs when standing. This shift in blood quantity decreases thoracic venous blood quantity and consequently central venous pressure decreases. This decreases right ventricular filling pressure (preload) leading of declination in stroke volume. Left ventricular stroke volume falls because of reduced left ventricular preload. This causes cardiac output to fall. This eventually causes dizziness or light-headedness. This is the motive why unexpected change in position from supine to upright is not advocated. Additionally, prolonged standing (upright) isn't always healthy because it leads to varicose veins [6].

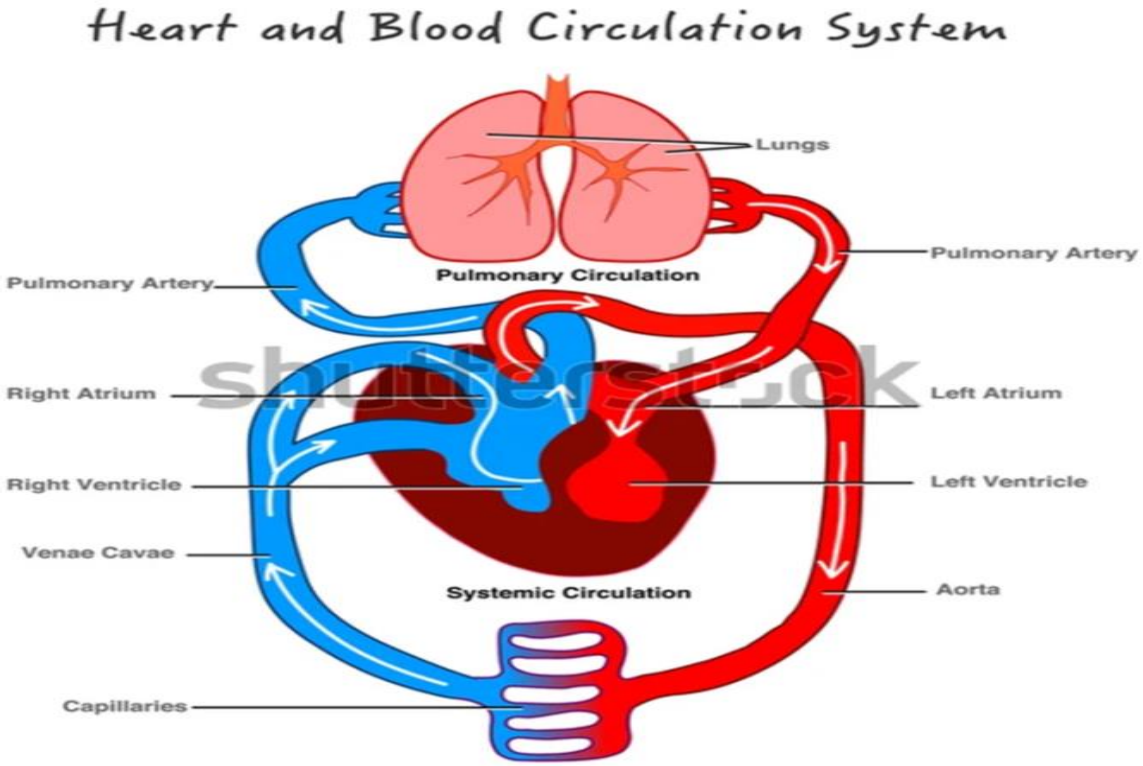

Figure 1 Heart and Blood Circulation System

4. Blood circulation in AIR (AERO)

Gravitational force of earth also plays major role on the blood circulation of a person in air.

4.1 Positive gravitation (+G Effect)

When a person is accelerating upwards (away from the earth), he experiences the +G effect.

This is because the gravitational force pulls the blood downwards where the blood accumulates in legs blood vessels. As blood is pooled in legs, less volume of blood reaches brain. This may cause the person to become unconscious. [11]

4.2 Negative Gravitation (-G Effect)

When a person accelerates downward, (towards earth), he experiences –G. This is because inertia overpowers gravitational force as body is accelerates downwards and blood in tends to move from feet to head. If this happens in a prolonged period, the person might suffer from headache [11]. G Suit of fighter pilot shown in Figure 2.

4.3 G Suits

A fighter pilot's G-suit also known as 'anti-G suit' is one-piece jumpsuit (as in fig 2) that protects pilot from feeling uneasiness and losing consciousness from pressure of G-forces bearing down on him. G-forces are forces of gravity that smack into the pilot as his aircraft speeds up in air; the faster he hastens or decelerates or banks the aircraft from previous path, more the G-forces. for instance, someone experiencing a roller coaster ride, would possibly revel in 3 Gs - two or three times his very own body

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weight pushing his head and body backwards at the time of swift parts of the ride. A fighter pilot elevating up rapidly, from a dive can experience up to 9 Gs pushing him in opposition to direction, which prevents his blood from rightly circulating in his body. For the reason that a person can lose consciousness dealing with such Gs, a fighter pilot needs to put on G suit, that is filled with a continuous flow of air. The air applies pressure on pilot's abdomen and legs so as to hold blood from collecting in specific regions and starving his mind. Additionally, a pilot's custom-outfitted helmet offers noise protection and cushions head, decreasing pressure of intense acceleration. [11]

Figure 2 G Suit of fighter pilot

5. Blood Circulation in Space (Space)

Many parts of cardiovascular system are stimulated by gravity. On this planet for instance, veins in our legs work in opposition to gravity to get blood returned to heart. Without gravity, however, heart and blood vessels alter and longer the flight the greater intense adjustments. The dimensions and shape of heart for instance modifies in presence of microgravity and the right and left ventricles decrease in mass. This could be because of a decrease in fluid quantity (blood) and adjustments in myocardial mass. A human heart rate is lower in space than on the planet. In fact, it's been found that heart rate of individuals standing upright at the International Space Station is just like their rate while laying down pre-flight on this planet. Blood pressure is likewise lower in space than on the earth. Muscular atrophy additionally contributes to decreased blood flow to lower limbs. As the astronauts arrive in microgravity and while they stay on International Space Station, blood and different body fluids are driven upward from legs and abdomen in the direction of heart and head. This fluid shift causes a decrease in amount of blood and fluid in heart and blood vessels even at the same time as astronaut's experience swelling in face and head. In microgravity the heart changes it's form from oval (like water-crammed balloon) to a spherical ball (an air-crammed balloon). Space causes the atrophy of muscle tissues that on this planet work to constrict the blood vessels so, they cannot manage blood go with the flow as well. On return to earth, gravity yet again "pulls" the blood and other body fluids into the abdomen and legs. The lack of blood vessels which can take place in space reduces the capacity to alter a drop in blood pressure that takes place whilst we stand on the Earth. Some astronauts experience orthostatic intolerance – problem or lack of ability to stand due to lightheadedness and/or fainting after returning to Earth. Workout in space is an effective way to maintain maximum types of cardiovascular health. "Equipment is now available on space station both for resistive physical activities, the use of the advanced Resistive exercising device (ARED) and aerobic sporting activities, using a treadmill or stationary bike." Further, astronauts can put on unique trousers that use pressure variations to drag blood again into abdomen and legs. [1] [4] [5]

6. Research Analysis

What we learn about physiological changes in space has important applications on ground as well, in part because many of the changes seen in space resemble those caused by aging on Earth. Important research is being done on the space station to learn more about SANS [Spaceflight Associated Neuro-ocular Syndrome] and to develop and test

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countermeasures to many possible different cardiovascular changes. [5]. Variation of blood circulation in different cases shown in Figure 3.

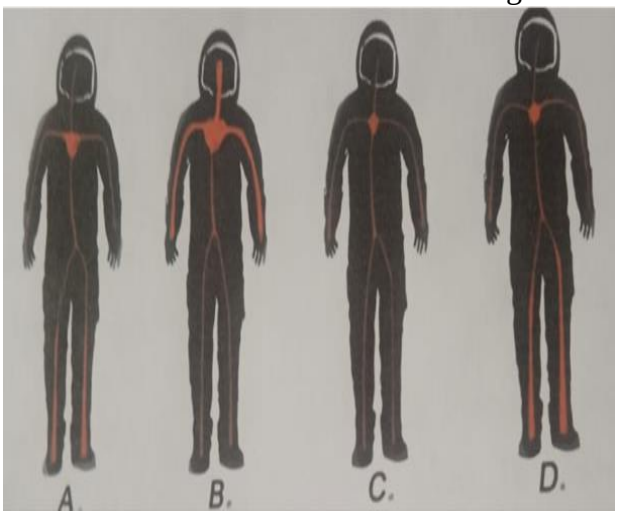

Figure 3 Variation of blood circulation in different cases

Conclusion

The Blood circulatory system is a system of organs that includes heart, blood vessels and blood which is circulated throughout entire body of a human or other vertebrate. Circulation of blood on land is normal unless there is a drastic change in position change from sleeping position to standing up straight and prolonged standing. When a body is falling in air towards the earth, it experiences the –G effect. This is because; blood rises upwards to head. When a body accelerates upwards away from the earth, it experiences the +G effect. This is because, blood rushes down towards legs. Use of G Suits is one of the best ideas to tackle with the consequences of G forces. When a person enters into microgravity environment, the pace of his blood circulation changes. It can cause muscular atrophy, blood pressure lowering etc. There are some researches going on, in space to study SANS.

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