**Script – Cardiovascular System Part 3: (The Pipes) Arteries and Veins**

**Introduction**

Welcome to the n-Lorem podcast series, I am Stan Crooke, the chairman and CEO of n-Lorem and the host of this podcast series. In our last couple of chats, we have been focused on the cardiovascular system. We have discussed the material that flows through pipes in the cardiovascular system, that’s blood. We have covered the heart, the pump. In this podcast, we plan to discuss the pipes. As I mentioned when we began the cardiovascular system, it has two sorts of pipes, one set is called the arterial system and the other set the venous system.

Arteries and veins differ very dramatically because they have very different jobs.

**Arteries**

Let’s begin with arteries. Of course, I know that you know a good bit about what we will be talking about. But let’s begin at the beginning. Most of the arteries in the body are responsible for managing blood flow under high pressure. They are the arteries that deliver blood from the left side of the heart to all the peripheral tissues except the lung. As you know, if your blood pressure is reasonably normal, you have a systolic pressure of 120 to 140 mmHg and a diastolic pressure of around 80 to 90 mmHg. Remember that systolic refers to the period when the left side of the heart is contracting, expelling blood at high pressure into the arteries. Diastolic refers to the period during which the left ventricle is filling and getting ready for the next contraction. So, you can see that even during the diastole, the pressure in the arteries is high. The arteries must deal with blood flowing at high pressure essentially all of the time.

I am sure a moment’s thought will convince you that the arterial system must be very muscular because the walls of the arteries must be strong enough to withstand extremely high pressure and very rapid blood flow. In fact, in some forms of high blood pressure, or hypertension, blood pressure during systolic can be as high as 300 mmHg. On the other hand, arteries also have to be very elastic because blood pressure can vary from very low to very high even in normal humans.

Key Point 1:

The peripheral arterial system is a high pressure, high flow system of pipes.

Key Point 2:

To manage blood flow at high pressures and at high flow rates, arteries are very muscular.

Key Point 3:

Arteries must also be highly elastic.

**The Structure of Arteries**

**Endothelium**

We know then that your arteries are going to be very muscular, so your arteries are made up of muscle fibers. To accomplish being elastic, the space between muscle fiber cells is made up of collagen and other very elastic materials. If you were to cut an artery open and look at it under a microscope, you would see an internal lining that is very thin, typically a single or few cells thick and that is called the endothelium. The endothelium is the surface over which blood flows. Of course, in an ideal situation the pipe is smooth so the liquid, in this case blood, flows smoothly. One job of the endothelium is to make sure that blood has a nice smooth surface to flow over. But you already know that cells wear out and die, so the endothelium is constantly being replenished by new cells. In addition, there are other cells in the endothelial surface that are designed to sense that there are issues or problems. Some of these cells can identify foreign materials or other problems and mount an inflammatory response to protect the artery from substances or organisms that could do harm. And, of course, you know that the cells involved in inflammatory responses are lymphocytes, macrophages, and the like. Many of these cells flow in blood and if there is an area in the surface of the artery that has a problem, these circulating cells pause or stop at that site to address the problem. Other cells involved in the inflammatory process are residents in the arteries themselves. Whether the cells are resident or transient, if inflammation becomes chronic, that is when the surface of the artery becomes ragged and begins to accumulate into what we call plaques. Remember that plaques in your arteries are called atherosclerosis, one of the most common problems in the developed world and a cause of many millions of deaths every year.

Another job that is a joint effort between blood and the endothelium of blood vessels is to keep you from bleeding to death. You will recall that I described all the clotting factors that are made in the liver and present in blood which are ready to go to work should a tear in one of the blood vessels occur. That said, the partner in this process is the blood vessel itself. Resident cells in the endothelium also recognize a rip or a tear in the lining of the blood vessel and help initiate the clotting process. You know very well that when you cut your skin, you go through a clotting process that ends up forming a scab and sometimes a visible scar. The exact same thing can happen in blood vessels. And what does that do? It makes the surface of the blood vessel no longer smooth, which can increase local turbulence and can cause inflammation, which can then lead to atherosclerosis.

Key Point 4:

The lining, or endothelium, of arteries is designed to keep the arterial wall smooth so that blood flows evenly.

Key Point 5:

The endothelium is an active part of the organ with new cells being made all the time and resident cells involved in inflammation and clotting.

Key Point 6:

Chronic inflammation can be caused by many factors, but when it happens, it can lead to atherosclerosis which is one of the great killers of modern man.

**Smooth Muscle**

Now let’s go back to the microscopic section of an artery. Once again, we are beginning on the inside working our way to the outer lining. Once you are through the endothelium, the next group of cells is smooth muscle cells. Smooth muscle cells are muscle cells, but they differ from skeletal muscle cells in their architecture and their innervation. The nerves that manage skeletal muscles are motor nerves, and you control them. The nerves that manage the smooth muscles, organs like blood vessels and the gut are autonomic nerves. Remember we discussed these earlier, autonomic nerves come in two flavors, adrenergic and cholinergic. For our purposes, you can think of adrenergic nerves as causing contraction of the smooth muscle and arteries. Of course, contraction means the blood vessel constricts and that raises blood pressure. Cholinergic nerves cause the opposite effect, they cause the smooth muscle to relax - Yin Yang. So every second of every day of your life, these two sets of nerves help you adjust your blood pressure and heart rate to manage all the different activities that you engage in and it is done without you ever having to think about it. Don’t forget adrenergic nerves secrete norepinephrine or noradrenaline, or what you think of as adrenaline. Cholinergic nerves secrete acetylcholine.

When atherosclerosis has progressed not only is the endothelium destroyed by the plaque, but so is the smooth muscle. When that happens the risk of a tear in one of your major arteries becomes much higher. Such an event is called an aneurysm and the most common artery to rip apart is the largest and most muscular artery that does the most work, the descending aorta. When that happens, that is a life and death surgical emergency, but aneurysms can happen anywhere in any vessel, including the small blood vessels in your brain.

When you go to a cardiologist for the first time, if they are very thorough, they will look at your eyes with that little tool that they use that shines the light in them. When they do that, they are looking at the blood vessels in your retina and often they can see evidence of atherosclerosis in those blood vessels. The point is that atherosclerosis can go on in all of your arteries and arterioles.

**Epithelium**

After the smooth muscle, the final layer in an artery is the epithelium, which is just the outside layer of the blood vessel. Like the endothelium, it is made up of multiple types of cells that constantly replicate to make sure that lining is intact and strong enough to withstand the pressure transferred to it from the muscle.

**Arterioles**

Arteries are arborized like trees. They branch into tinier and tinier elements and eventually become arterioles. Arterioles are a cell layer or two thick, and they are designed to supply oxygen and nutrients to tissues, and to collect carbon dioxide and other waste.

**Veins**

Veins are very different from arteries because they move blood at low pressure and slow flow back to the heart. Remember the pressure on the venous side of the cardiovascular system is 5 to 8 mmHg. Blood flows in veins up from the legs for example, through a process called peristalsis. Peristalsis is the kind of movement that moves food through your digestive tract. Since the veins are managing a low pressure, low flow system, the smooth muscle layer of veins is small. In the larger veins like the vena cava the muscular layer is bigger.

Naturally, since flow is slow in veins, it is rare that there is a problem with veins ripping because they have atherosclerosis. The more common problem is that blood may pool which can lead to a clot. That is why when you are on a long plane ride, doctors advise you to get up and walk or at least flex and relax your legs. Deep vein clots are potentially very dangerous because the clot can break off and go to the lungs, brain, or heart and cause serious problems.

Of course, veins also must sense whether there has been an externally caused rip in a vein and clot to stop the bleeding. Veins use the same system that is used by arteries. When you take blood thinners or anticoagulants, they don’t thin your blood. They prevent clotting in some way. The reason you take them is to avoid clots that form in your veins or perhaps your heart that could cause problems. But because they are not the greatest drugs, meaning that their therapeutic index is not large, when you take them, you often have nosebleeds and bruises.

**Pulmonary Arteries and Veins**

You will recall that the pressure on the pulmonary side of the vascular system is about the same pressure as in veins, 5 to 15 mmHg. So pulmonary arteries are not nearly as muscular as, say, the aorta. They divide into tiny arterioles just as would happen in peripheral tissues. The architecture in the lung is extremely important as I mentioned. Each little air sac, or alveoli, must have a little capillary. The reason you have such pain and are at risk of dying from a pulmonary embolism is that it disrupts the balance between the alveoli and the capillaries. That produces extreme lung dysfunction. On the other hand, if you are a smoker and had lung cancer that was local, you could have one of your lungs removed and breathe just fine, because when you remove the lung, you remove all the alveoli and all the capillaries and the lung is balanced.

**Pulmonary Veins**

Pulmonary veins are just like the veins in the other peripheral tissues except that they eventually drain into the left atrium providing oxygenated blood for the left ventricle to pump to all the peripheral tissues.

Key Point 7:

Systemic arteries are highly muscular and elastic, and they eventually divide into arterioles and capillaries. Veins, because they manage low pressure, have much less muscle than arteries.

Key Point 8:

The pulmonary vascular system manages blood flow at about the same pressure as the veins, so is different from the systemic vascular system.

**Conclusion**

Now you know all about the pump, the heart, the fluid, the blood, and the pipes, the arteries and veins. In our next lesson in the series, we will finish the system by talking about the spigot, the kidney. Then, you will be ready to pass your boards so you can be a board certified cardiologist.