

B.5.4. The Veins

Purpose: The function of the veins is to transport blood from the capillaries back to the heart. This is the case for both the systemic (large) circulation as for the pulmonary circulation.

A. There is a problem here!

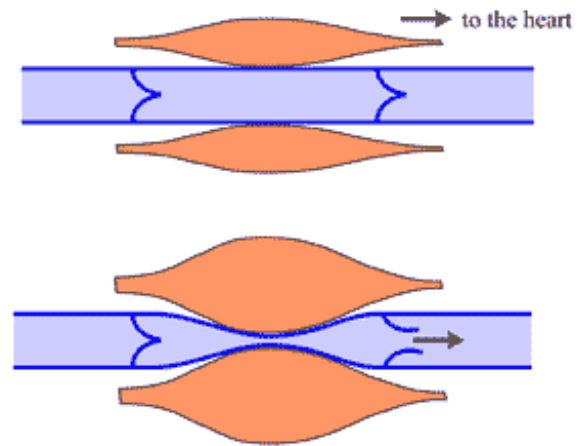
1. The Problem: In the arterial system there is a pump (the heart) that pumps the blood through all the arteries to the capillaries. However, there is no “venous pump” in the venous system to pump the blood back to the heart.	2. So, the problem is; how does the venous blood return to the heart? There are several factors that help in this and together they take care of what we call the Venous Return.
3. These are the 6 factors that help/promote the blood to flow back to the heart: 1. Valves 2. Muscle Pump 3. Capillary Pressure 4. Respiratory Pump 5. Arterial Pump 6. Cardiac Pump	4. Not all factors have the same importance. The first is the most important, no. 5 and 6 are the least important.

B. Factors that promote the Venous Return:

1. Valves: In contrast to the arteries, the veins have valves. These valves make sure that blood can flow in only one direction; towards the heart. That helps a lot!	 The diagram shows a horizontal blue vein. Inside the vein, there are four crescent-shaped valves pointing to the right. Above the vein, the text 'to the heart' is written, followed by a black arrow pointing to the right.
2. Muscle Pump: Probably the most important factor. When a skeletal muscle contract (which is often), the veins inside and between the muscles will be squeezed. This will increase the blood pressure inside the veins and make the blood flow away from the high pressure. Because of the valves, the blood will only	

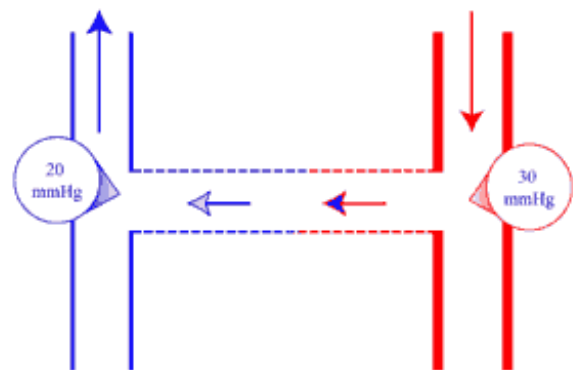
flow in **one direction**, towards the heart.

Since skeletal muscles mostly contract rhythmically (such as walking, running, cycling), this will induce a rhythmic blood pressure in the veins and therefore a rhythmic flow of venous blood towards the heart.



3. Capillary Pressure:

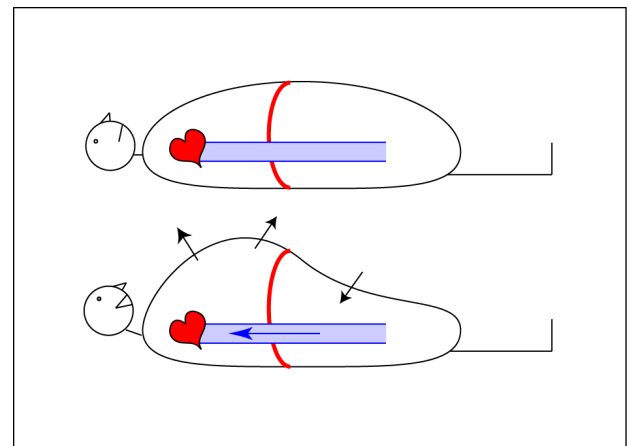
Another factor in the venous return is the capillary pressure. At the end of the capillaries, the hydrostatic (= blood) pressure is not zero but approximately 20 mm Hg. As the pressure in the big veins is much lower, close to 0 mmHg, there is therefore a pressure gradient from capillaries to veins which will cause blood flow through the veins to the heart. That helps!



4. Respiratory pump (=breathing):

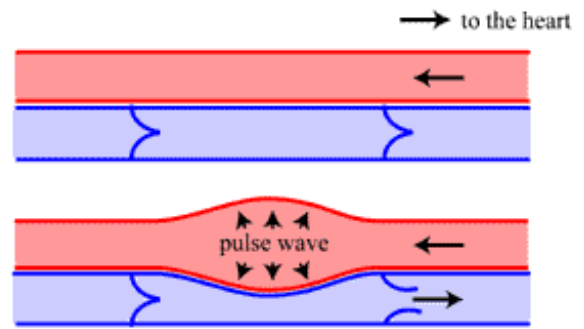
When a person inhales, the pressure inside the chest gets lower (becomes more negative). At that moment, the pressure in the chest is lower than in the abdomen. This will induce a flow of blood in the large abdominal vein (vena cava inferior) towards the chest.

And, when a person exhales, the pressure in the chest is higher than in the abdomen, and that will stop the blood flow (note that the blood will not flow back because it is blocked by the valves in the femoral veins).



5. Arterial Pump:

In the body, the arteries and veins often run parallel to each other. Therefore, when an arterial pulse propagates down the artery, this will cause a local expansion (bulging) and this swelling will push against the veins. This will increase the local pressure in the veins. This pressure increase will push the venous blood towards the heart.

**6. Cardiac Suction:**

This is a very small effect that is caused by the movement of the heart during its contraction. When the heart contracts, it ejects blood into the aorta and into the pulmonary heart. This ejection is quite a force that will cause the ventricles to move away from these major arteries (action = reaction; here blood ejection is the action and the movement away is the reaction).

Anatomically however, the atria are located between the root of the major vessels and the ventricles. The major vessels are fixed in the chest (actually in the mediastinum), so, as the ventricles move away during ejection, the atria will be stretched. This will cause a lower pressure in the atria and will help venous blood flow, from the vena cava's and the pulmonary veins, into the atria.

C. Some additional notes:

1.

As stated before, not all factors are equally important and the order of importance is pretty much the order discussed above. The **valves** and the **muscle pump** are the most important factor whereas the arterial pulse and the cardiac suction are the least important.

2.

If the valves are deficient, venous return will become more difficult. If the valves become deficient in a particular area, then that area will have a problem in its venous return (swelling, oedema etc). This is for example the case with **varicosities**. This tends to occur in those people who, by profession, have to stand a long time (shopkeepers, teachers). Over the years, the valves will slowly deteriorate, expand, and blood will pool in those areas. These are visible as ugly swellings under the skin: **varicosities**.

3.

We often use our muscle pump, especially when standing, because then the blood has to flow back from the legs all the way to the heart. During normal standing, we often use muscles without noticing it, to keep our muscle pump working. This can be done by walking (teachers in front of the class), or

4.

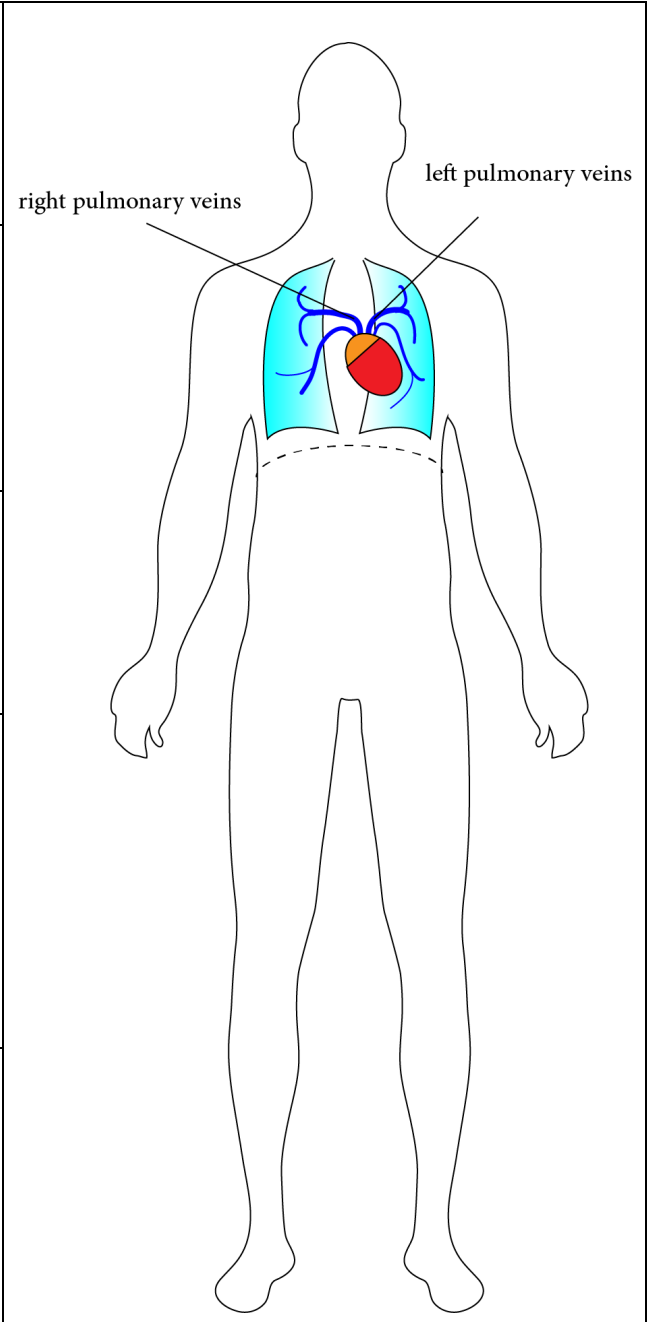
In some situations, people are told to stand absolute **immobile**. Soldiers for example in a parade. It is then not uncommon for a soldier to **faint** (this often happens during the summer, then you see pictures of such a poor fellow lying flat on the parade grounds). The reason why this person fainted is because he has to

by shaking legs etc.	stand absolute motionless, he is not allowed to move a single muscle, his venous return became too low, which in turn decreased his cardiac output, therefore not enough blood flowed to his brain, hence he fainted!
5. The reason why this occurs more often during the summer is that the soldier, because of the high temperature outside, develops a high body temperature (especially if they have to wear thick ceremonial clothing or wear battle gear). To get the body temperature back to normal, the circulation in the skin must open (see Special Circulations). But this compromises even further the cardiac distribution, leaving less blood to flow to the brain. The result is fainting.	6. The nice thing about fainting and collapsing on the floor is that this behaviour often solves the problem. Before collapsing, the venous return was too much reduced because it had to pump upwards to the heart. This is about 1 meter higher than the legs. If one is collapsed and lying flat on the ground, then the legs are at the same level as the heart and it is much easier for the blood to flow back to the heart and to the brain. You can actually help by lifting the legs when the fainted person is on the floor to increase blood flow from the legs to the heart.

D. The Systemic Venous Tree:

1. As with the arterial system, I will also give you here a sketch of the venous “tree”.	
2. The important thing here is that the venous tree is not an exact (reverse) copy of the arterial system. There are actually more vessels to help flow the blood back to the brain.	
3. In the arms and the legs, the veins are very similar to the arteries although there are, again, a few more vessels.	
4. What is really important are the major veins in the body. The superior and inferior caval veins (= vena cava superior and inferior). These are the major thoroughfares for the blood to flow back.	

E. The Pulmonary Venous Tree:

1. And this is my sketch of the veins in the pulmonary system.	
2. Again, there are more veins than arteries, just like in the systemic circulation.	
3. Noteworthy here is that, usually, two large veins run from each lung to the heart, to the right atrium.	
4. However, there are some anatomical variations between individuals. For example, in some people, the two veins from the right lung for example, merge into a single vessel before entering the right atrium.	
5. And, as with the arterial system, don't forget that these vessels, together, allow 5 litres/min blood to flow back to the atrium. And this is at rest!	