

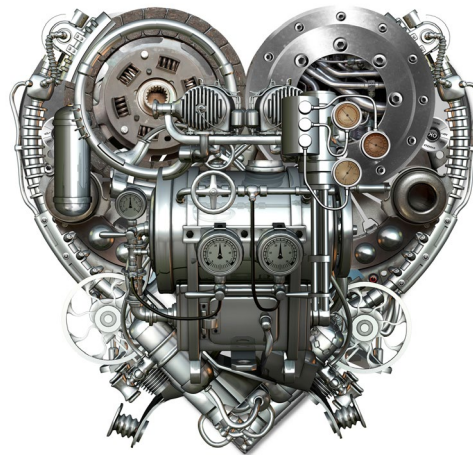
# Cardiac Blood Flow: A Circulatory Story

by

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## Part I – Heart Anatomy

Josie was a 43-year-old former college athlete who enjoyed staying at home with her three young children. Even though she had always tried to maintain an active healthy lifestyle, over the past several months Josie had felt increasingly tired to the point that she sometimes was unable to do normal household activities like cooking dinner or folding laundry. Initially Josie chalked up her exhaustion to “just being 40-something,” but following an episode where she awoke in the middle of the night feeling very short of breath, she decided to see her primary care physician. Upon listening to her heart with a stethoscope, her doctor referred her to a cardiologist.

Three weeks later, Josie was sitting nervously in the cardiologist’s exam room waiting for him to enter. This was her second appointment with Dr. Adams, and the plan was to discuss the results from her physical examination, labs, and echocardiogram. She heard footsteps coming down the hall, a rustling of papers at the door, and then a quick knock before Dr. Adams poked his head in. Josie and her doctor exchanged pleasantries before Dr. Adams became more serious and took a seat in his exam chair across from her.

“Josie,” he began, “based on the results of the tests we ran last week and your physical exam, I am diagnosing you with congestive heart failure.”

Josie’s head was spinning. That sounded serious—potentially life-threateningly serious! Her mind raced. *I’m too young for this... I’ve always lived a healthy lifestyle and expected a different result... This isn’t fair! What will my kids do if I die?*

Dr. Adams continued. “I recognize this is a shock. I want you to know that as your doctor, I’m here to help you develop the best possible plan to ensure the greatest quality of life despite this diagnosis. What questions do you have right now that I can help with?”

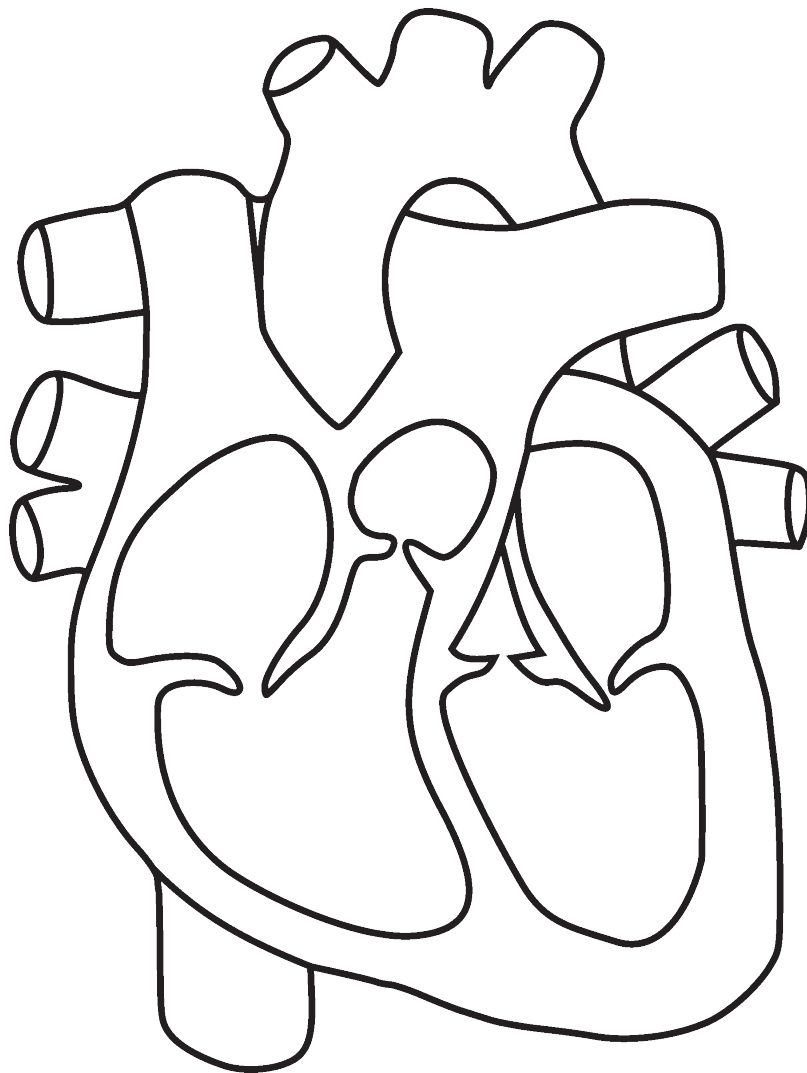
“Uh...what is congestive heart failure?” Josie stammered. “Am I going to die?”

“Let me explain to you a little about the anatomy of the heart and its function to help you better understand this disease,” was Dr. Adams gentle reply.

## Questions

1. Label the following on Figure 1 (next page): *right atrium, left atrium, right ventricle, left ventricle, bicuspid valve, tricuspid valve, aortic semilunar valve, pulmonary semilunar valve.*
2. Label the blood vessels on the diagram: *inferior vena cava, superior vena cava, pulmonary trunk, pulmonary arteries, pulmonary veins, and aorta.*
3. List the order that blood passes through each of the structures you’ve labelled, beginning with the inferior and superior vena cava.

4. Use markers, crayons, or colored pencils to color the chambers of the heart and blood vessels either red or blue, depending on how highly oxygenated the blood contained within them is. Highly oxygenated blood is bright red, so color areas containing highly oxygenated blood red and those containing blood with lower oxygen levels blue.
5. Explain why there is a difference in oxygen content of the blood on the two sides of the heart.



*Figure 1.* Longitudinal section of a human heart. *Credit:* PD, <<https://www.goodfreephotos.com/albums/vector-images/human-heart-vector-clipart.png>>.

## Part II – Circuits of Blood Flow

Dr. Adams continued with his teaching “The right side of the heart pumps deoxygenated blood to the lungs, while the left side of the heart pumps highly oxygenated blood that has just returned from the lungs to all the tissues of the body. With congestive heart failure, your heart has weakened, and it doesn’t pump as effectively. Less blood and therefore less oxygen gets to your tissues and organs. Josie, this is why you’ve felt so tired and also short of breath.”

### Questions

1. In your own words, define *pulmonary circuit* and *systemic circuit*.
2. Based on where they must pump blood to, which side of the heart do you think must pump harder, right or left? Explain your answer, and use anatomical evidence from the heart to support your argument.
3. Based on what you’ve learned so far, which side of the heart do you think more commonly weakens faster and fails first? Explain your answer.

## Part III – Blood Flow in Heart Failure

“I took a human anatomy class in college and remember learning about the systemic and pulmonary circuits,” Josie responded. “I always found them kind of confusing because the textbooks would show them as a figure eight with the heart at the center, and with all the valves inside and the vessels coming off of the heart. I got confused about where the blood was moving.”

“I’ve got a picture that I think may simplify that for you quite a bit and help you to understand what is going on with blood flow in your body. Take a look at this,” Dr. Adams said as he handed Josie a paper with a diagram on it (Figure 2).

“Let me explain this to you,” he continued. “I think it will simplify the circuits and help you to understand how blood is moving through the body, and why there is a problem if one or both sides of the heart fail. This leaves out all of the additional anatomy so that you can just focus on the left side of the heart being a pump that moves blood from the pulmonary circuit to the systemic circuit, and the right side of the heart a pump that moves blood from the systemic circuit to the pulmonary. The arrows in this diagram can help you remember in which direction the blood is moving.”

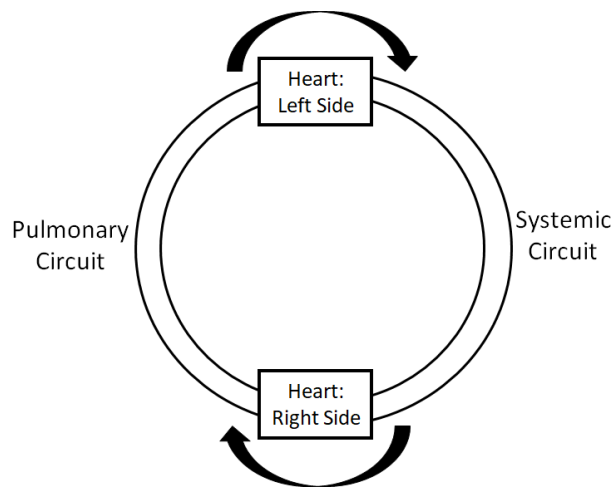


Figure 2. Simplified representation of pulmonary and systemic circuits.

## Questions

1. If the left side of the heart fails, where in the circulation would blood back up? What about the right side?
2. Fill-in-the-blanks: *Blood flow into the \_\_\_\_\_ (pulmonary circuit/systemic circuit) would \_\_\_\_\_ (increase/decrease) if the left side of the heart fails. Blood flow into the \_\_\_\_\_ (pulmonary circuit/systemic circuit) would \_\_\_\_\_ (increase/decrease) if the right side of the heart fails.*
3. Describe what would happen to pressure in the blood vessels where blood is backing up and pooling due to failure of the heart.
4. Capillaries are by far the most common type of blood vessel in the body, and most capillaries are very porous—they leak fluid. Blood is mostly fluid. The swelling caused by fluids leaking from the blood into tissues is known as edema. Predict where in the body you would see edema related to left-sided heart failure, and where you would see edema related to right-sided heart failure. Be sure to explain your answers.
5. Describe why heart failure is so often referred to as “congestive” heart failure.
6. If the left side of the heart were failing, how would this change the pressure that the right side of the heart needed to generate to continue moving blood into the pulmonary circuit?
7. Left-sided heart failure is the primary cause of right-sided heart failure. Explain why this might be.
8. Feeling short of breath was one of the symptoms that led Josie to see her doctor originally. What do you think happens to oxygen levels in the blood when the left side of the heart fails? Explain your answer and discuss why Josie has been feeling short of breath.

## Part IV – Blood Flow and Valve Issues

“This all makes sense,” Josie said, “but what I don’t understand and what I’m really frustrated about is I’ve always been active! Until I became too exhausted to do anything I worked out regularly. I eat a healthy diet. I don’t smoke! I don’t have any of the risk factors that would predispose me to this disease, so why do I have it? Why me?”

“Josie, you have a narrowed bicuspid valve that has caused the problem. It’s possible this was a congenital heart defect that was never noticed and didn’t cause a lot of problems until your heart was permanently damaged. It’s also possible that damage was caused to the valve by an infection like rheumatic fever. Unfortunately, congestive heart failure isn’t something that can always be prevented.”

### *Questions*

1. How would a stenotic bicuspid (mitral) valve affect the movement of blood from the left atrium to the left ventricle?
2. Which of the four chambers of the heart would have its workload increased the most by a stenotic bicuspid (mitral) valve? Explain your answer.
3. Suppose it were the pulmonary semilunar valve that were stenotic. Which of the four chambers of the heart would have its workload increased the most and why?
4. Describe how a stenotic valve increases the risk of heart failure.
5. In Josie’s case congestive heart failure was caused by a stenotic bicuspid (mitral) valve. However, other valve abnormalities can also cause heart failure. Define valve regurgitation and explain how it could also lead to a failing heart.