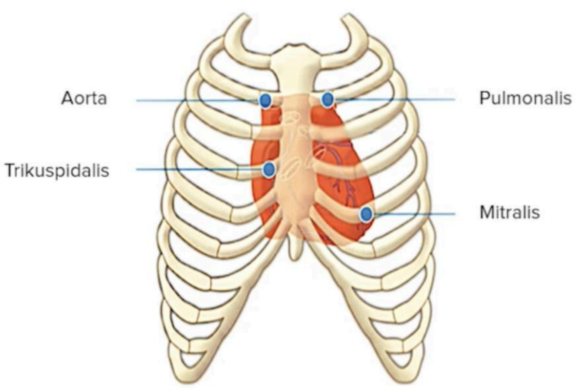
VIDEO 1: CARDIOVASCULAR SYSTEM: ANATOMY OF THE HEART BY LECTURIO

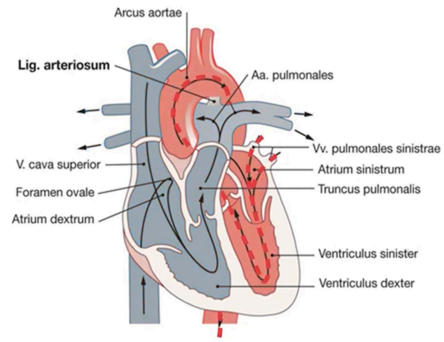
The Anatomy of the Cardiovascular System

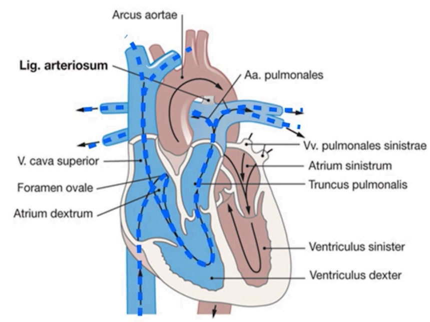
- The heart is not heart shaped!
  - The heart is conical in shape with a rounded point (not a sharp point).
- The heart in embryonic life starts out as a tube that folds on itself and develops into 4 Chambers.
- The heart is a pump.
  - It is a muscle pump that keeps the circulation continuously going in a circle.
- The blood circulates in a never ending circle.
  - What happens is the heart pumps the blood out full of oxygen and nutrients to the cells throughout the body.
  - Then, waste products are given to the blood. The blood returns to the lungs a deep blue and is then reoxygenated (gets oxygen again) and pumped out to the body. There's a continuous circle going on of the circulation.



- Here's a diagram that shows how the heart lies in the chest
- Notice that it is not directly in the center of the chest. In fact, it is slightly to the left. In this view, it looks like it's to the right, but if you were standing behind this person where the heart bulges out it would be to the left. You can see four points are marked on this skeleton with the heart drawn behind it.
- Behind the ribs and the breast bones which we call the sternum, you can see that there are four heart valves and the points that are marked are the places where we listen with our stethoscope when we want to hear that particular valve:
  - Aortic Valve
  - Pulmonic Valve
  - Tricuspid valve
  - Mitral Valve

VIDEO 2: CHAMBERS OF THE HEART BY LECTURIO





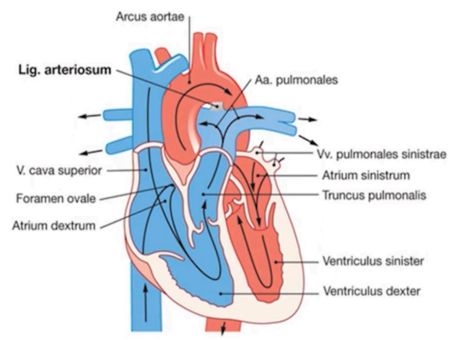


Diagram of the circulation:

- It's made in two colors: blue for the blood that's returning to the right side of the heart.
  - It's exhausted of its oxygen.
  - It's carrying waste products, particularly carbon dioxide.
- Carbon dioxide will be given off in the lungs.
- Oxygen will be introduced to the red blood cells and then they will get to the left side of the heart where they'll be pumped out to the body.

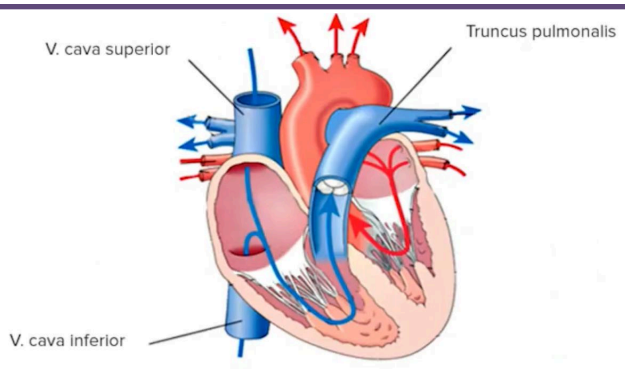
Circulation through the heart:

- There are two large veins here that drain into the right atrium:
  - **Superior vena cava**: drains the blood from the upper body
  - **Inferior vena cava**: drains the blood from the lower body.
- They both empty into the right atrium and then pass through the tricuspid valve into the right ventricle.
- They are pumped out through the pulmonic valve into the lungs.

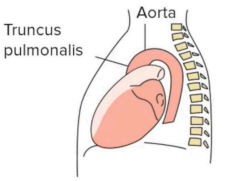
- They return through pulmonary veins to the left atrium and then across the mitral valve into the left ventricle.
- The left ventricle pumps it out through the aortic valve to the aorta and to the whole body.

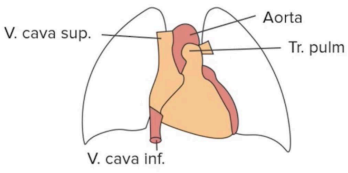
- What you see here is a small catheter working its way through the heart. That's how we measure pressures and the flow the the amount of blood that the heart is pumping during a diagnostic catheterization.
- But again, the blood is not exactly this color blue on the right side of the circulation.
- It's a little bit darker and it's quite bright red on the arterial side.

A more anatomically correct diagram

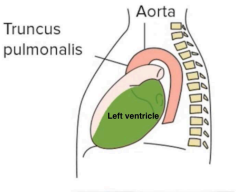


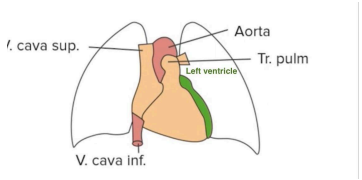
- Notice the superior vena cava, the inferior vena cava, coming into the right atrium draining the deoxygenated or tired blood into the right atrium
- You can see the tricuspid valve as the blood passes into the right ventricle and then it is being pumped out into the pulmonary artery still all in blue
- What's of interest here is that the left ventricle is a lot thicker than the right ventricle. In fact, their shapes are slightly different. It's because they have very different functions. The pressure in the lung is quite low, so that the right ventricle functions like a Bellows like the blacksmith uses to create air for his fire that he's going to be melting and working on horseshoes, for example. It produces large volumes of blood movement at low pressure.
- The left ventricle has to pump blood throughout the body. It has to pump that blood at a much higher pressure.
- And consequently, the walls of the left ventricle are much thicker than the walls of the right ventricle. It's functioning not like a Bellows, but rather like the piston in a car, a high pressure chamber that does a lot of pressure work, as opposed to the right ventricle which does a lot of volume work at much lower pressure.



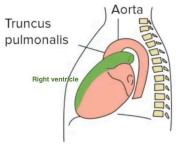


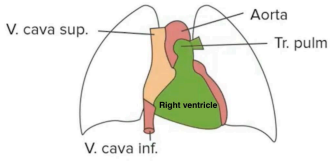
- Now here we see the heart diagrammed in comparison to the chest x-ray
- Notice that the heart is not in the center of the chest but in fact is a little bit more in the left chest than the than the right chest





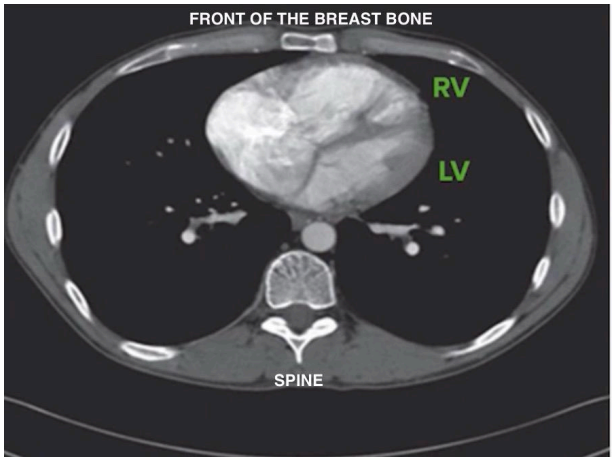
- The bulge down in the left chest is actually the **left ventricular outline.**





- If you want to see the **right ventricle**, you have to look at the lateral View and you see it in front of the left ventricle
- The heart actually has the right ventricle in front of the left ventricle. We'll see that on some further x-rays and magnetic resonance image which will show you that in fact the right ventricle does lie in front, closer to the breast bone than the left ventricle which lies a little bit behind.
- and you can get a hint of that from the the two diagrams here that are reflecting what you see in the chest x-rays

MRI of the chest



- **Top:** front the breast bone
- **Bottom**: spine.
- **Middle**: heart
- **RV**: right ventricle
- **LV**: left ventricle
- Note: The right ventricle is lying in front, that is closer to the chest front wall compared to the left ventricle

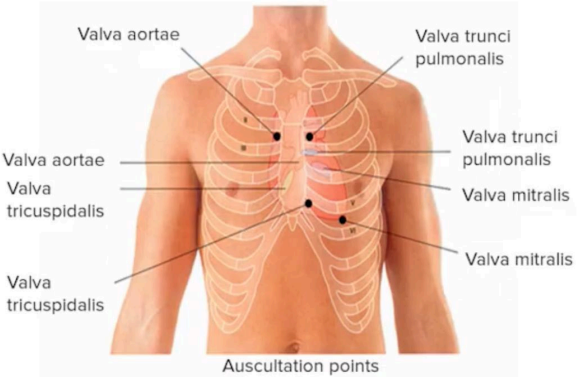
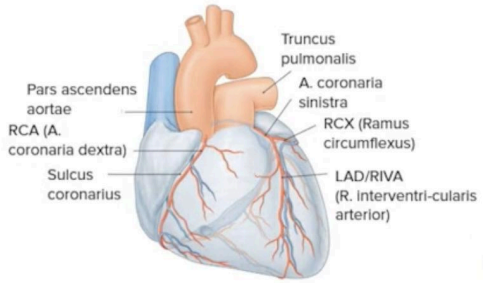


Diagram that shows where the heart is located and where the different points are that you can best hear, with your stethoscope, the sounds made by the four heart valves.

VIDEO 3: ARTERIES AND VEINS BY LECTURIO

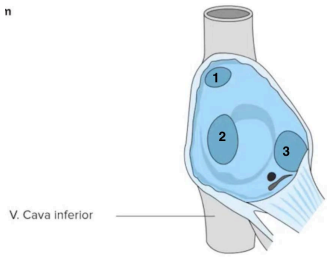
- The arteries carry nourishment and oxygen to the working myocardial cells thereby enabling contraction
- If inadequate blood reaches the myocardial cells, their contractile function deteriorates
- The venous system of the heart drains "depleted" blood from the heart muscle and empties it into the right atrium for eventual passage to the lungs



CORONARY ARTERIES

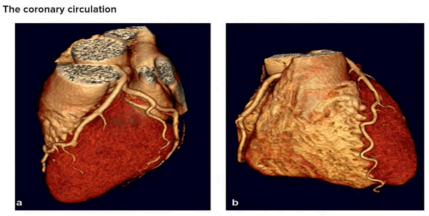
- The coronary arteries are like the fuel line in your car. If you don't have a good open fuel line, and gasoline doesn't get in, or diesel fuel doesn't get in your motor, you know what happens. The motor doesn't function. The same is true about the heart.
- It needs oxygenated blood to nourish it and to enable it to continue to do its mechanical activity
- The heart is a remarkable organ. Remember it beats constantly. It has to continue beating if you want to stay alive
- it's a remarkably strong muscle that is very resistant to injury, except when certain diseases occur. but in fact often tries to do its best job even when injured.
- **Two main coronary arteries:** *left coronary artery* and *right coronary artery*
- In a **triple coronary bypass**, the third coronary artery occurs because the left coronary artery branches early on after its origin. It branches into the ***left anterior descending coronary artery*** and the ***left circumflex coronary artery.*** So, the two main arteries very quickly divide into two main branches. That's how we have the three coronary arteries

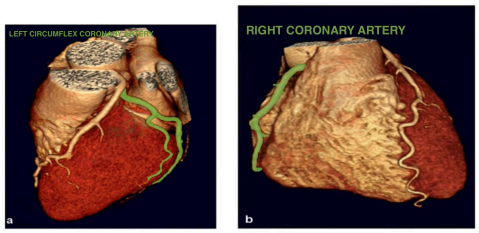
Return of venous blood to the heart

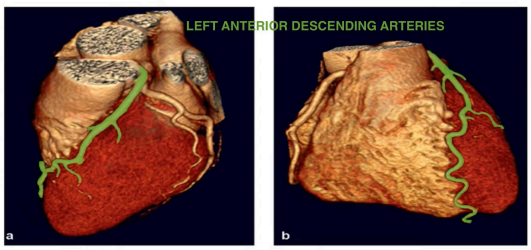


inside of the right atrium:

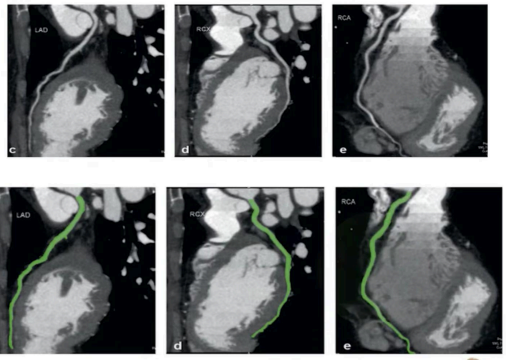
- These three circles represent the venous drainage coming into the heart
- **1:** the entrance of the blood from the superior vena cava. That blood enters the right atrium and drains the the venous blood from the upper part of the body
- **2**: that's the one from the inferior vena cava that's draining blood from the bottom of the body
- **3**: **Coronary sinus.** That's the heart's venous system coming back in because the heart is getting blood. It has to have venous return to the heart, so it also returns to the right atrium.
- The upper part of the body & the lower part of the body and the heart all drain into the right atrium. They pass through the tricuspid valve into the right ventricle. They're pumped to the lung where the blue blood becomes red as it takes on oxygen and gives off carbon dioxide.







- **right coronary artery** - supplies the right ventricle, part of the septum (the wall between the left and right ventricles), and part of the back of the heart
- **left anterior descending coronary artery** - supplies the front of the heart, and part of the septum
- **left circumflex coronary artery** - supplies the lateral wall of the heart, and also part of the back of the heart
- Blockage at any one of these can cause a ***myocardial infarction*** or a ***heart attack***



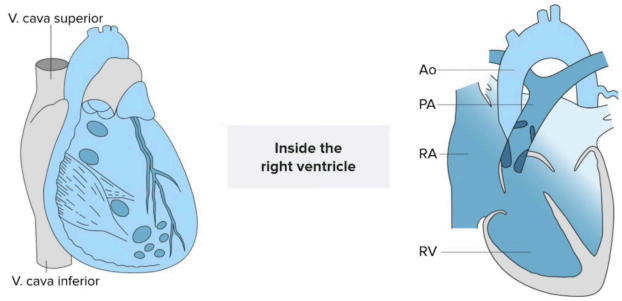
- You can see very clearly the coronary arteries coming off the left, the right, the anterior descending, and the circumflex

PERICARDIUM

- the **pericardium** is the constraint (the protective covering)
- A tough membrane that encloses the heart in a sac-like structure
- It's the “plastic bag” that keeps the heart nicely shaped within the chest.
- It doesn't allow the heart to over-expand and protects the heart as well.
- It's filled with a little bit of fluid so that the heart is able to move smooth within the pericardium.
- When disease happens to the pericardium, and it becomes thickened, and/or weeps fluid into that space = restriction of heart function.

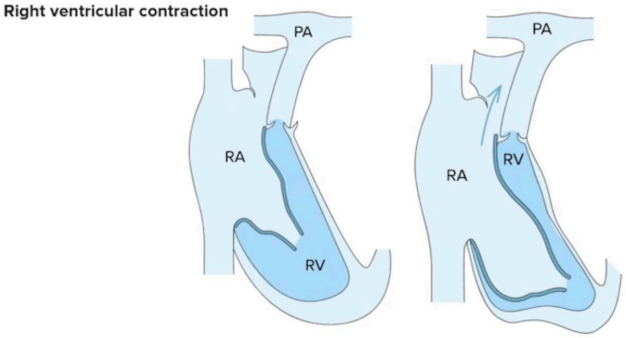
VIDEO 4: COMPONENTS OF THE HEART BY LECTURIO

- The heart has 6 important components:
    - **Muscle**- the heart is a muscle pump
    - **Valves** - You have to have valves to keep the blood flowing in the right direction. If you didn't have valves, all the blood would just slosh back and forth within the heart. You have to have the valves to keep the blood flowing in the right direction.
    - **Electrical Wiring** - what triggers the contraction of the heart is an electrical signal that starts high in the right atrium of the heart with a little automatic Pacemaker, and passes right down through the heart muscle and results in contraction of the heart muscle when the electrical signal gets there.
    - **Arteries** - supply the heart with oxygen and nutrients so it can work. in other words, the fuel line for the heart to put the fuel into the heart cells so they can contract.
    - **Veins** - carry the tired blood, the blood that's lost its oxygen and some of its nutrients and is carrying waste products. it returns to the right atrium along with the superior and inferior vena cava to be circulated again from the right ventricle into the lungs to gain oxygenation and to give up its carbon dioxide.
    - **A protective covering** (the pericardium) - the entire heart is contained in a membrane (a very tough membrane) called the pericardium that protects the heart, for example from infections in the lung, should they occur. It also keeps the heart in a nice shape so that it doesn't expand too much when it's working.
- The heart is a muscle pump that continues to pump blood in a continuous circle through the body and that it is meticulously and beautifully adapted
- The right ventricular muscle wall is rather thin
- The left ventricular muscle wall is quite thick
- The muscle walls of both right and left atria are very thin
- At the microscopic level, the myocardium consists of row upon row of muscle fibers filled with the biological machinery that results in contraction
- The right ventricle is a low pressure pump that functions like a blacksmith's bellows
- The left ventricle is a high pressure pump that functions like the piston in a car engine

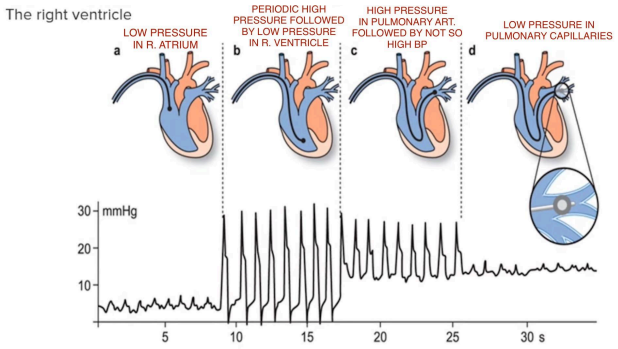


inside these various Chambers:

- here you see a diagram inside the right ventricle
- you can see it shows you the blood is blue –that's the deoxygenated blood
- you can see the right atrium above uh the right ventricle
- and you can see the pulmonary artery and
- the pulmonary valve uh below it
- there are a variety of abnormalities that the heart:
    - found in infants, for example, the pulmonary valve can be stenotic or closed. It has to be fixed at the early in life
    - there can be holes in the heart, for example, a connection between the right and left ventricle where there should be none
- All of these are the areas of the pediatric cardiologists who can make those diagnoses very early in life. And often these days, infants are operated on and have these abnormalities corrected .
- **REMEMBER**: The normal right ventricle will be separated from the left ventricle with a muscle septum that will prevent blood from the right side from getting onto the left side
- when blood from the right side gets onto the left side, the patient actually has a faintly bluish tinge to themselves.



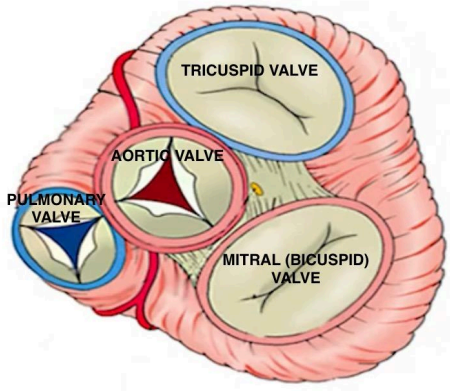
LEFT: contracted right ventricle
RIGHT: the filling right ventricle



- The blood passes through the heart starting at a very low pressure in the right atrium, the tricuspid valve opens, blood flows into the right ventricle, and it squeezes and then you see the pressure going up for the right ventricle
- And then when the pulmonary valve closes, the pressure falls again down to the baseline where the tricuspid valve opens again and blood flows into the right ventricle
- Out in the pulmonary artery when the pulmonary valve closes, the pressure no longer falls anymore and you see a sort of baseline pulmonary artery pressure that's transmitted across to the pulmonary capillaries and eventually to the pulmonary veins and the left atrium

VIDEO 5: VALVES AND ELECTRICAL SYSTEM BY LECTURIO

- There are **4 valves in the heart**
  - two for the right side of the heart
  - two for the left side
- Three of the valves (**tricuspid**, **pulmonic**, and **aortic**) have 3 leaflets.
- The mitral valve has only two leaflets.
- The valves keep the blood flowing in forward fashion through the heart chambers.



the ones in blue are the right-sided ones. the ones in red are the left-sided one

- What we're seeing here is the right and left ventricular systole (aka squeeze). You see that the pulmonary valve and the aortic valve are open and blood is flowing respectively into the pulmonary artery through the pulmonic valve and into the aorta through the aortic valve

Tricuspid Valve

- tricuspid means three cusps
- three components
- there are three parts to the tricuspid valve
- so the blood is now passing through the tricuspid valve into the right ventricle and then there's going to be right ventricular contraction, squeeze, and the blood is going out the pulmonary artery

Pulmonary Artery Valve

- it's open because the right ventricle is squeezing blood through it
- The blood goes to the lungs, gets oxygenated, picks up oxygen, comes back through the pulmonary veins to the left atrium, and then passes through the mitral valve

Mitral (Bicuspid) Valve

- has two cusps
- is between the left atrium and the left ventricle
- it resembles its name for for The Bishop's miter, which is the crown that the bishop wears in the Catholic Church which basically has just two sides to it
- once the blood is in the left ventricle, the left ventricle contracts, and the blood goes out the aortic valve

Aortic Valve

- in the center
- it's also open

The electrical system = The cardiac conduction system

- The electrical system ensures that the heart contracts in an efficient and coordinated manner.
- The sinus node, high in the right atrium, initiates the electrical activity of the heart.
- From the sinus node, a wave of electrical activity passes through all the muscle cells of the heart
- The electrical wave triggers myocardial contraction.

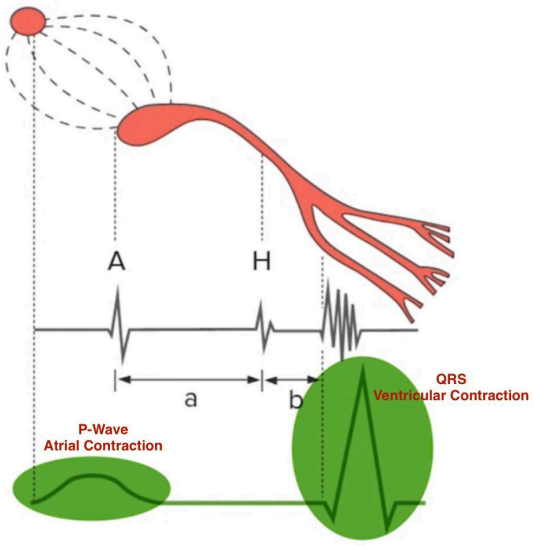
- It's the electrical system which is the trigger for mechanical contraction.
- Without the electrical system, the heart muscle will not contract.
- Each heart cell responds to the electrical activity by contracting. This electrical activity starts at the top of the atrium. There is a pacemaker, an automatic pacemaker, which can be influenced by adrenaline circulating or by nerves from the brain. It can accelerate or it can decelerate depending upon a variety of conditions
- But in any case the impulse starts spontaneously, it passes through a number of little fibers in the atrium into what you see that little bulb (AV node).
- It pauses there for a little bit. Why does it pause? You can't have the atria and the ventricle contracting at the same time. And if the impulse traveled rapidly through, you would have them contracting at the same time, and the blood wouldn't be going anywhere So there's a certain pause while the atria finish their mechanical contraction, and then the electrical activity passes down from that AV node, also called the Bundle of His, down into the branches that are in the ventricle.
- And at that point, the ventricular muscle contracts.

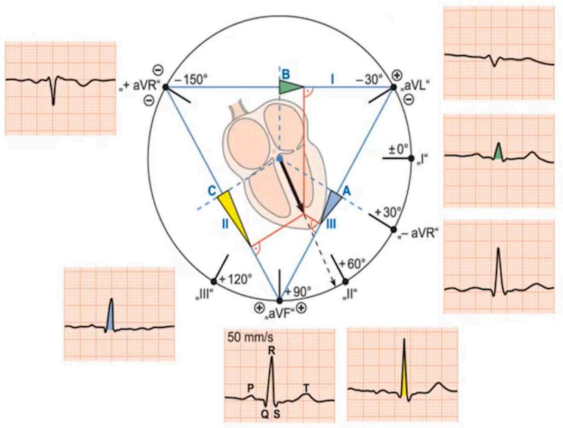
ELECTROCARDIOGRAM

- the first wave is called the **P-Wave** (atrial contraction)
- the big deflection is called the **QRS** (ventricular contraction)

- You can even see the heart sounds in there with atrial contraction and ventricular contraction. You can see the first and second heart sounds
- In fact we record the electrical impulse passing through the heart with something called the electrocardiogram
- The diagram shows *six electrocardiographic leads*.
- They're taken in the frontal plane. They're taken from different angles.
- They are a little electrical biopsy from different angles around the heart and we put all of this information together.
- It helps us to diagnose specific forms of heart disease. It also tells us a lot about how well the wave of depolarization is passing through the heart. Are there abnormalities in the

electrical conduction system? Or are there abnormalities in some of the minerals in the blood, for example potassium?





VIDEO 6: THE CARDIAC CYCLE ANIMATION BY ALILA MEDIA

- The **cardiac cycle** refers to the sequence of events that occur and repeat with every heartbeat.
- It can be divided into **2 major phases**: systole and diastole, each of which subdivides into several smaller phases.
- Systole and diastole, when not specified otherwise, refer to ventricular contraction and relaxation, respectively.
- **Basic principles:**
  - Blood flows from higher to lower pressure.
  - Contraction increases the pressure within a chamber, while relaxation lowers the pressure.
  - Valves open/close according to pressure gradients. AV valves open when atrial pressures are higher than ventricular pressures and close when the pressure gradient is reversed. Similarly, semilunar valves open when ventricular pressures are higher than aortic/pulmonary pressures, and close when the reverse is true.
- The cycle is initiated with the firing of the SA node that stimulates the atria to depolarize. This is represented by the P-wave on the ECG. Atrial contraction starts shortly after the P-wave begins, and causes the pressure within the atria to increase, forcing blood into the ventricles. Atrial contraction, however, only accounts for a fraction of ventricular filling, because at this point, the ventricles are already almost full due to passive blood flow down the ventricles through the open AV valves.
- As atrial contraction completes, atrial pressure begins to fall, reversing the pressure gradient across the AV valves, causing them to close. The closing of the AV valves produces the first heart sound, S1, and marks the beginning of systole.
- At this point, ventricular depolarization, represented by the QRS complex, is half way through, and the ventricles start to contract, rapidly building up pressures inside the ventricles.
- For a moment, however, the semilunar valves remain closed, and the ventricles contract within a closed space. This phase is referred to as isovolumetric contraction, because no blood is ejected and ventricular volume is unchanged.
- Ventricular ejection starts when ventricular pressures exceed the pressures within the aorta and pulmonary artery; the aortic and pulmonic valves open and blood is ejected out of the ventricles. This is the rapid ejection phase.
- As ventricular repolarization, reflected by the T-wave, begins, ventricular pressure starts to fall and the force of ejection is reduced.
- When ventricular pressures drop below aortic and pulmonary pressures, the semilunar valves close, marking the end of systole and beginning of diastole.
- Closure of semilunar valves produces the second heart sound, S2. The first part of diastole is, again, isovolumetric, as the ventricles relax with all valves closed.
- Ventricular pressure drops rapidly but their volumes remain unchanged.
- Meanwhile, the atria are being filled with blood and atrial pressures rise slowly. Ventricular filling starts when ventricular pressures drop below atrial pressures, causing the AV valve to open, allowing blood to flow down the ventricles passively.
- The atria contract to finish the filling phase and the cycle repeats itself.