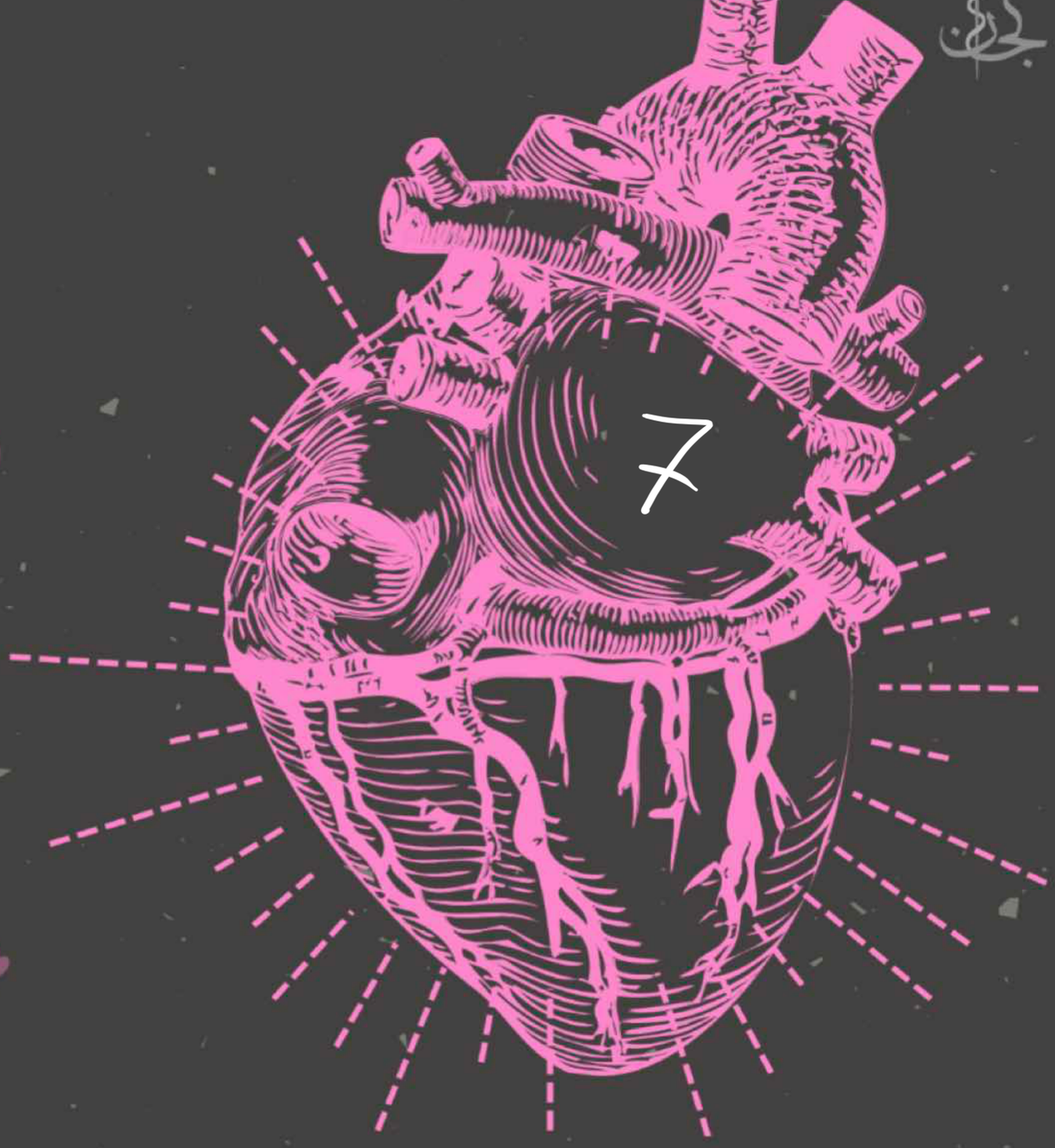
CVS



PHYSIOLOGY

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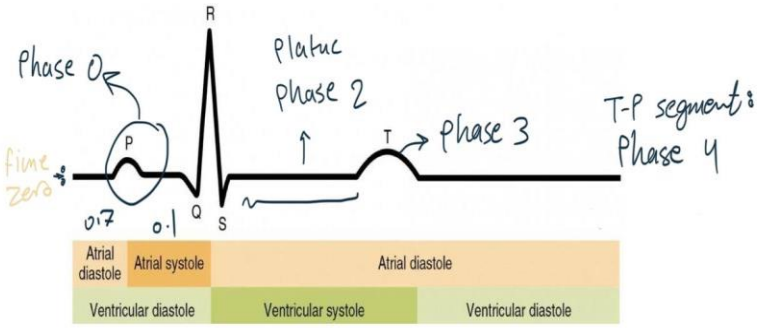
The cardiac cycle

- **The cardiac cycle:** is the cardiac events that happens from the beginning of one heartbeat to the beginning of another.
- Each cycle is initiated by spontaneous generation of an action potential in the SA NODE.
- The cardiac cycle consists of a period of relaxation (ventricles do not contract) called diastole, during which the heart fills with blood, followed by a period of contraction called systole.
- One cardiac cycle (one heartbeat) normally takes 0.8 sec (20 small squares on the ECG). So, per minute we have about 75 beats (in other words, the heart rate=75 beats/minute.)
- If your heart rate increases, for any reason, up to 100 beats/minute. In this case, 0.6 sec is required for each cardiac cycle (15 small squares on the ECG) => in 1 minute, we will have more heart beats.
- When a cardiac cycle takes 1 sec (25 small squares on the ECG), the HR is reduced to 60 beats per minute.

❖ The picture below represents the normal ECG



P wave: recorded before atrial systole

QRS: recorded before ventricular systole

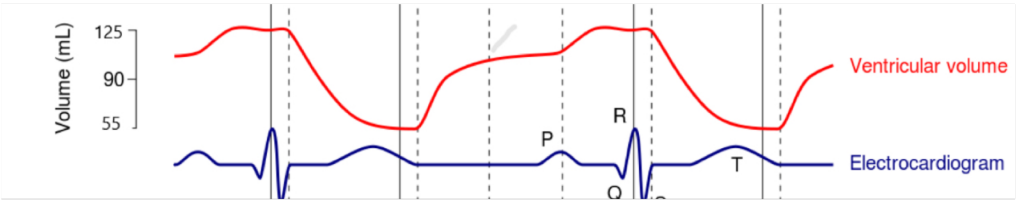
T wave: recorded before ventricular diastole

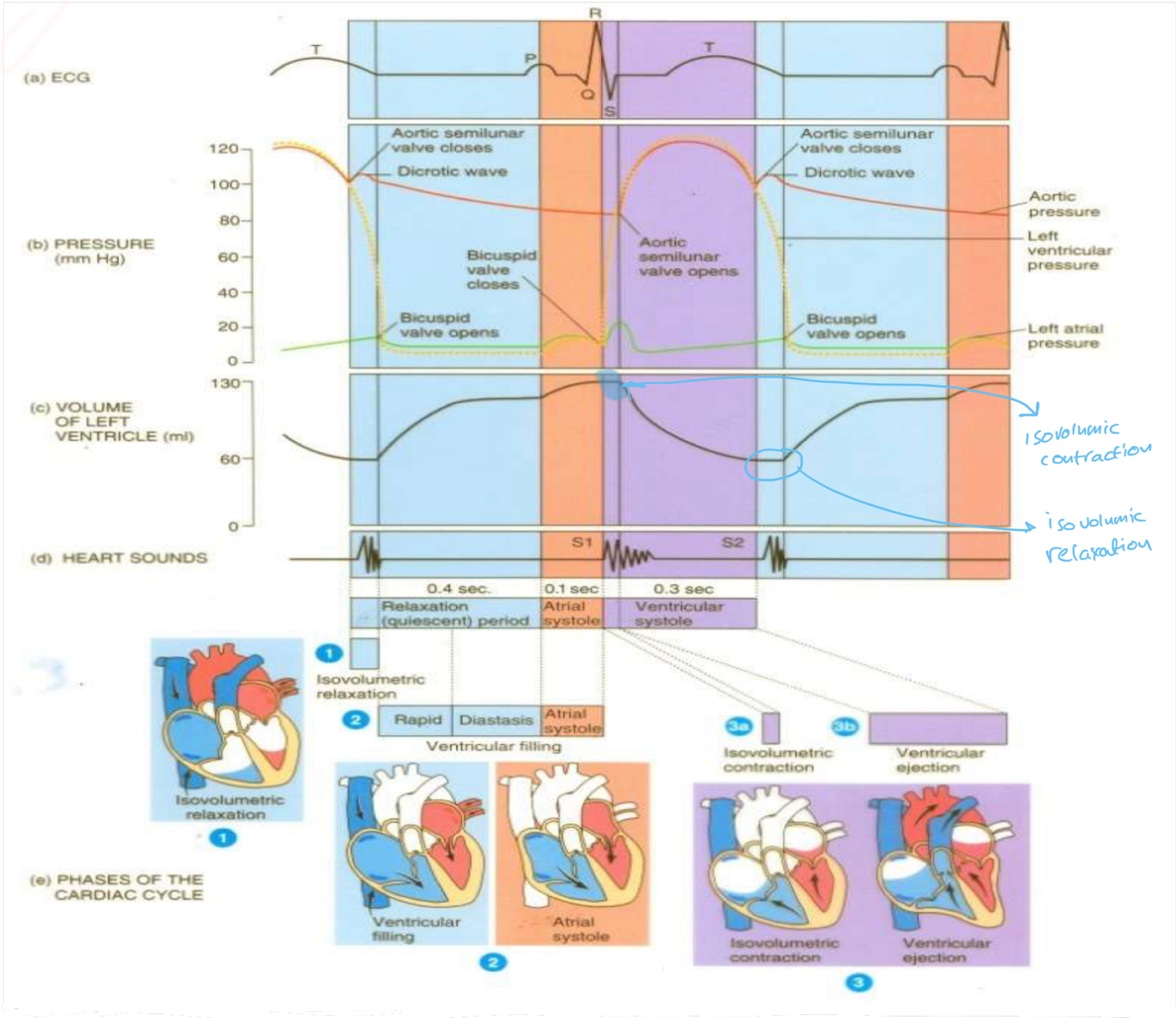
- Recall that the P wave is caused by spread of depolarization through the atria and is followed by atrial contraction (atrial systole), which takes about 0.1 seconds. Then, atria relax (atrial diastole), and that takes about 0.7 seconds.
- QRS waves, as we already know, appear because of electrical depolarization of the ventricles, which initiates contraction of the ventricles (ventricular systole). This (ventricular contraction) takes about 0.3 seconds. Ventricular Relaxation (ventricular diastole) takes about 0.5 seconds.
- Atria and ventricles could overlap during the diastole (at the normal ECG they overlap for 0.4 sec), but not during systole.
- **Note:** The atrial conductive system is organized so that the cardiac impulse does not travel from the atria into the ventricles too rapidly; this delay allows time for the atria to empty their blood into the ventricles before ventricular contraction begin.

Other changes during the cardiac cycle:

- Volume changes:

  Ventricular volume changes:





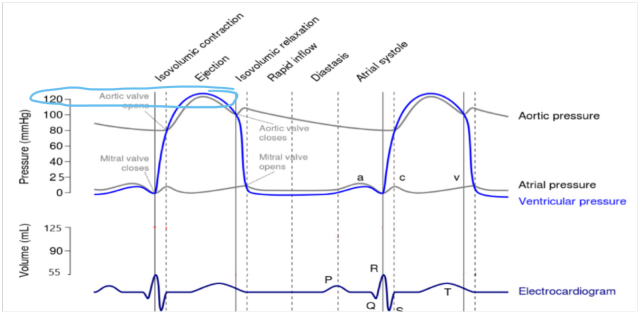
This picture sums up all the cardiac cycle , the doctor recommended trying to draw it

- Volume changes in both, the left and right ventricles, are the same.
- Before the atrial systole, the ventricular volume of blood is 100 ml. Once the atria contracts, the volume will increase to reach 125 ml (end diastolic volume). So, its contribution to the diastolic volume is around 25 % (maximum) and could even be less.
- When the ventricle contracts, rapid ejection of the blood takes place, because the blood in the ventricle was at a high pressure, after that the blood ejection slows down.
- Once ventricular systole is over, around 55 ml of blood remains in the ventricle => (end systolic volume).
- When the AV valve opens, the blood moves from atria to ventricles in three stages:
  1- Rapid filling
  2- Slow filling (diastasis)
  3- Atrial contraction (last stage of ventricular filling)

AV valve is opened, why?

The atrial pressure during diastole of the ventricle is higher than the ventricular pressure

Pressure changes:



- The Aortic pressure during ventricular diastole is around 80 mm Hg, and the pressure in the ventricle, at the same time, is almost zero mm Hg.
  So, when atria contract, the pressure in ventricles increases a little bit reaching about 5 mmHg. However, and since the semilunar valves are closed, the pressure in the aorta/pulmonary artery remains intact.
- Once the pressure in the atria (about 2mmHg) becomes higher than that in the ventricle (about 0 mmHg), AV valves open, and the blood flows toward the ventricles, and when the atria contract, they push the blood to the ventricles so fast, so the ventricular pressure increases a little bit.
- When the ventricles are about to contract, the pressure inside them increases, so the pressure becomes higher than that in the atria, so the AV valves close.
- At this particular moment, when all 4 valves are closed (2 semilunar, aortic, pulmonary), the first part of ventricular contraction takes place. This is known as **isovolumic contraction**.
  As the name indicates, the volume of blood inside the ventricles doesn't change. However, the pressure increases sharply. Here we are taking the left side of the heart as an example. This happens because the pressure in the left ventricle has not yet exceeded the pressure in the Aorta (semilunar valve is closed). When the ventricular pressure becomes higher than that in the aorta, the semilunar valve opens, and the blood is pumped from the left ventricle to the aorta. It is important to know that the pressure in the ventricle is still going up, and at the same time the pressure at the aorta will go up too but still less than the pressure in the ventricle (around 1 mm Hg less).

What prevent AV valve to be open?

Cordea tendinea

- At the end of systole, the pressure in the ventricle becomes a little bit less than the pressure in the aorta. Yet, the blood keeps going from the ventricle to the aorta because of the momentum of the blood الزخم then the pressure in the ventricle starts to fall as the volume of the blood starts decreasing.

- When the pressure at the aorta becomes higher than the pressure in the ventricle, the semilunar valve closes. At this moment the 4 valves are closed, and this very short period is known as **isovolumic relaxation.**

At the end of isovolumic relaxation, the AV valve is open, why?
Because the atrial pressure is higher than the ventricular one

- Then, the pressure drops down until it becomes around zero. When this happens, AV valve opens, so blood starts to flow to the ventricle increasing the pressure and another cycle starts, the pressure in the aorta drops back to 80 mm Hg.

✓ The highest pressure in the ventricle during systole is around 120 mm Hg, and the highest-pressure during systole in the aorta is around 118 mm Hg.

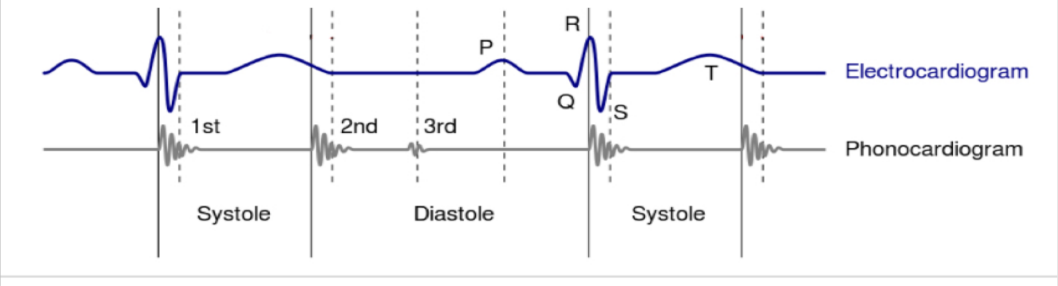
✓ When measuring the blood pressure from the arm we say that the pressure is 120/80 mm Hg, which means that the pressure during the systole in the aorta is 120 mm Hg, and the pressure during the diastole is 80 mm Hg.

- The pulmonary pressure during the diastole equals 8 mm Hg, and during systole equals 25 mm Hg. Keep in mind that whatever happens in the left side of the heart happens in the right side (the only difference lies in the pressure values in the right and left chambers)
- The pressure of the right ventricle during diastole equals almost zero mm Hg, and during systole it's 25 mm Hg.

NOW,

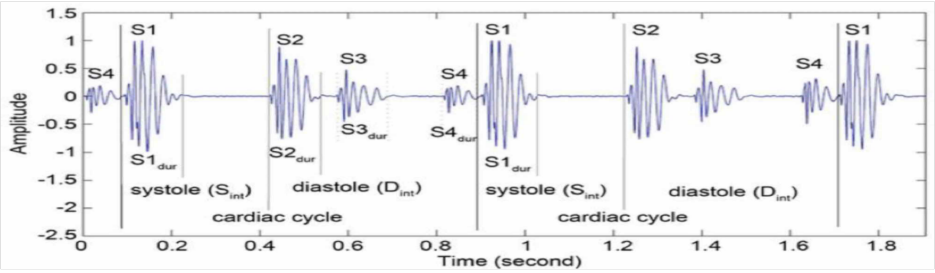
- When heart rate increases, the duration of each cardiac cycle decreases, including the contraction and relaxation phases. The duration of the action potential and the period of contraction (systole) also decrease, but not by as great a percentage as does the relaxation phase (diastole). Even though the stroke volume may get affected (reduced), the cardiac output will still be increased (due to increased heart rate).
- With each beat, we start with end diastolic volume (EDV) and end with end systolic volume (ESV). Having said that, the difference between EDV (125 ml) and ESV (55 ml) is called the stroke volume (SV), which equals the amount of blood ejected from the left or right ventricle per beat, and we use SV to calculate the cardiac output, which can be calculated by multiplying SV with the heart rate.
- So, if the EDV equals 125 ml, and ESV equals 55 ml, SV = 125 – 55 which equals 70 ml, and when the HR equals 75 bpm, the CO = 70 * 75 = almost 5L/min.

Changes in sounds:

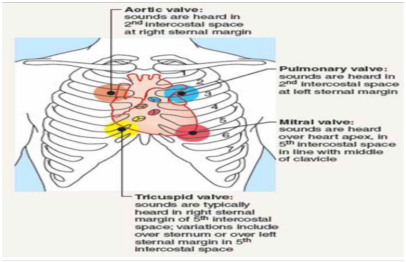


- Auscultation = listening to heart sound using stethoscope
- Once the AV valve closes, the blood tries to go back from the ventricle to the atrium, but because the pressure in the ventricle, now is higher than that in the atrium" during ventricular systole", blood remains sequestered in the ventricle.
- The two major sounds heard in the normal heart sound like "lub dub". The "lub" is the first heart sound, commonly termed S1, and is caused by turbulence caused by the closure of AV valves at the start of systole.
- The second sound," dub" or S2, is caused by the closure of semilunar valves, marking the end of systole.

- The period elapsing between the first heart sound and second sound defines systole (ventricular ejection) and the time between the second sound and the following first sound defines diastole (ventricular filling).



- Incisura or dicrotic notch wave is caused by semilunar valve closure. When the valve closes, the pressure around the valve increases because blood accumulates near the valve as it tries to go back to the ventricle, which increases the aortic pressure.



- When the AV valve opens after the isovolumic relaxation,

  you might hear a third cardiac sound (S3) which is the sound of blood flow from the atrium to ventricle.
  Another sound (S4) is the sound of atrial systole.

General notes
> why do we have Delay in the cardice cyele?
: to make sure that the systoles don't occur toyether
> Prior to
: Just befor, No time between 2 events
> coincide:
Two events synced together [at the same time]
>right and left ventricles have The same variables [volume, ejection time]
-> the cardiac cycle= atrial systole, ventricle systole and then the diastoles with an over all of
0.4 second + 0.1 atrial systole + 0.3 ventricular diastole = 08 cardiac cycle .