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Lecture title: Cardiac Cycle

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Summary: Cardiac cycle includes systole and diastole phases, detailing heart chamber pressures, valve actions, ECG changes, and blood flow dynamics.

Cardiac Cycle

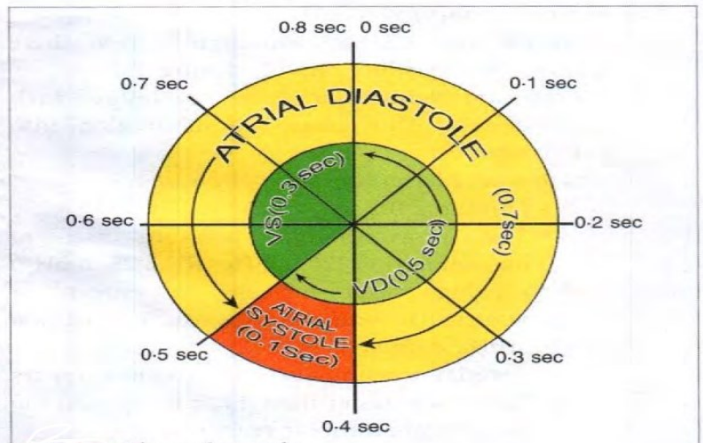
*The cardiac events (*the sequence of changes in the pressure and flow in the heart chambers and blood vessels) *that occur from the beginning of one heart-beat to the beginning of the next beat are called the* ***cardiac cycle.***

- At rest the cycle is 0.8 seconds in duration if the heart rate is 70 beats per minute.
- Each cycle is initiated by **spontaneous generation** of an **action potential** in the **sinus node**, spread down to the AV node and resting myocardium.
- The cardiac cycle consists of a period of **relaxation** called ***diastole***, during which the heart fills with blood, followed by a period of **contraction** called ***systole***.
- Blood normally flows continually from the great veins into the atria; about 80% of the blood flows directly through the atria into the ventricles even before the atria contract. Then, atrial contraction usually causes an additional 20% filling of the ventricles. This is why the atria considered as ***primer pump***. Due to its function as primer pump the increase in the ventricular pumping effectiveness reach 20% additional force. However, the heart can continue to operate under most conditions even without this extra 20% effectiveness because it normally has the capability of pumping 300 to 400% more blood than is required by the resting body.

Events of cardiac cycle

Mechanical Events of the Cardiac Cycle

- The cardiac cycle is divided into systole (contraction) and diastole (relaxation).
- Ventricular systole: 0.3 sec; ventricular diastole: 0.5 sec; atrial systole: 0.1 sec and atrial diastole: 0.7 sec.



The cardiac cycle
(Normal duration: 0.8 sec at heart rate of 75 per min)
VS and VD: Ventricular systole and diastole respectively.

Phases of cardiac cycle:

1. Atrial systole. 0.1 sec. — late ventricular diastole
2. Isovolumetric contraction phase.0.05 sec. — ventricular systole
3. Maximum ejection phase.0.15 sec. — ventricular systole
4. Reduced ejection phase. 0.1 sec. — ventricular systole
5. Protodiastolic phase = 0.04 sec. — early ventricular diastole
6. Isovolumetric relaxation phase. 0.06 sec. — early ventricular diastole
7. Rapid filling phase.0.1 sec. — early ventricular diastole
8. Slow filling phase. 0.2 sec. — mid ventricular diastole

Phases of cardiac cycle:

A. Atrial systole (Atrial Contraction Phase):

- Duration 0.1 sec. It is seen following the impulse generation in the SAN.
- The atria contract and pump 25- 30% of blood into the ventricles.
- The AV valves are opened and semilunar valves are closed.
- Ventricular pressure: increase
- Atrial pressure: increased due to atrial contraction then decreased as blood passes to ventricles.
- Ventricular volume: increased and at the end it reaches the end diastolic volume (EDV)= 135 ml.
- Aortic pressure: decrease due to flow of blood from it into arterial tree.
- Heat sounds: 4th heart (normally non audible: recorded by phonocardiogram) caused by atrial contraction and pumping of blood into ventricles.
- ECG: p wave begins before atrial contraction (0.02 sec.)

B. Ventricular Systole:

*Total duration: 0.3

1- Isovolumetric contraction phase:

- Duration 0.05 sec.
- Ventricular pressure: increased rapidly from 0 to 80 mmHg (in Lt. ventricle)
- Ventricular volume: constant
- Atrial pressure: small sharp increased (due to bulging of the cusps of AV valves into the atria).
- The AV and semilunar valves suddenly close by ventricular contraction.
- The ventricles contract in a closed space their volume is constant (isovolumetric).
- Heart sound: 1st heart sound (caused by sudden closure of the AV valves).
- ECG: Q wave begins before this phase (by 0.02 sec.) and QRS coincides with it.

2- Maximum ejection phase:

- Duration 0.15
- Ventricular pressure: increased to 120 mmHg (in Lt. ventricle) and 25 mmHg (in Rt. ventricle).
- As the pressures in the left and right ventricles exceed the pressures in the aorta (80 mmHg) and pulmonary artery (10 mmHg) lead the blood is ejected forcibly and rapidly.
- Opening of semilunar valves.
- Ventricular volume: decrease due to ejection of blood.
- Aortic pressure: increased (120 mmHg) (as blood coming to aorta is < that leaving it)
- Atrial pressure: sharp decrease due to pulling down of AV valves.
- ECG: T wave begins in this phase.

3- Reduced ejection phase:

- Duration: 0.1 sec.
- The ventricles to eject blood less forcibly.
- Ventricular pressure: decrease gradually.
- Ventricular volume: decrease and at the end it reaches the end systolic volume (ESV)=50ml.

- Aortic pressure: begins to decrease (as blood coming to aorta is <that leaving it)
- Atrial pressure: increase due accumulation of venous return.

C. Ventricular Diastole:

Duration:0.5 sec.

1- Protodiastolic phase:
   - Duration 0.04 sec.
   - It is a transition period between the end of systole and start of diastole (decrease ventricular pressure).

2- Isovolumetric relaxation phase:

   - Duration 0.06 sec.
   - The semilunar valves suddenly close (to prevent regorge of blood from aorta and pulmonary artery).
   - The ventricles start to relax and their pressure decreased without change in ventricular volume.
   - Ventricular pressure: decrease rapidly to 0 mmHg.
   - Ventricular volume: constant.
   - Aortic pressure: decrease.
   - Atrial pressure: increase by venous return.

- Heart sound: 2nd heart sound (caused by sudden closure of semilunar valves).

3- Maximum (rapid) filling phase:

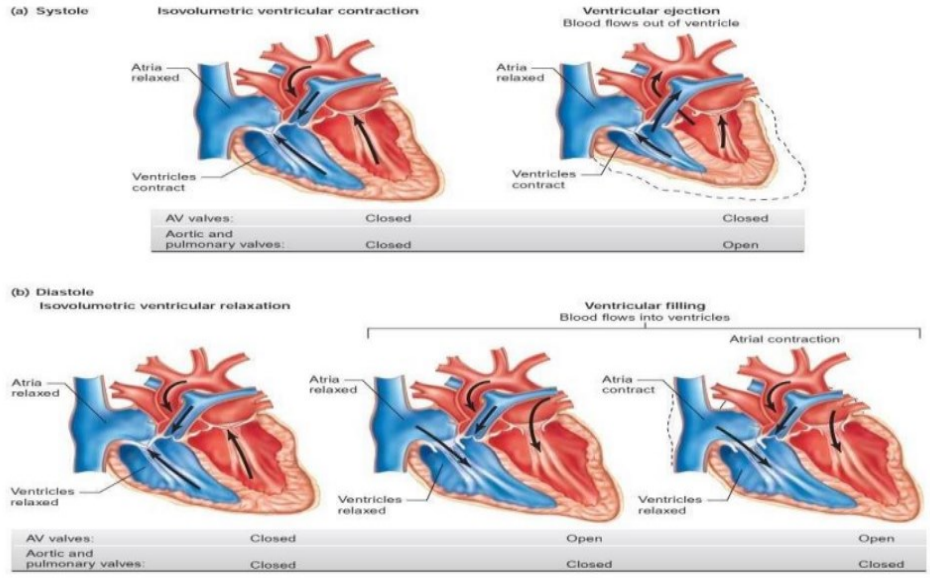
   - Duration: 0.1 sec.
   - The AV valves open.
   - As atrial pressure >ventricular pressure blood pass rapidly into the ventricles.
   - Ventricular pressure: decrease as ventricles relax more.
   - Ventricular volume: rapid increase.
   - Aortic pressure: decrease (as blood leaves aorta to tissues).

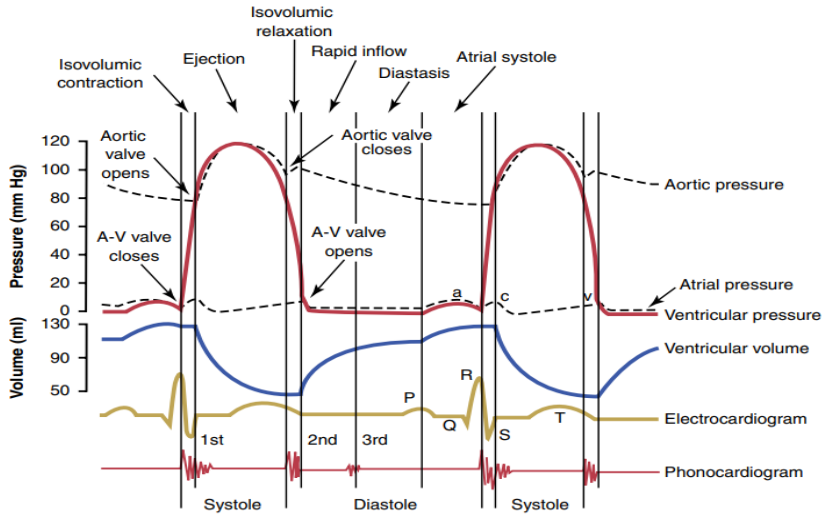
- Heart sounds: 3rd heart sound (caused by vibration of blood into the ventricles).

4- Reduced(slow)filling phase:

   - Duration: 0.02
   - The blood continues to flow slowly into the ventricles.
   - **During the last 2 filling phase**s about 70-75% of blood phases passively (along pr. Gradient) from atria to ventricles.

- Ventricular pressure: not increase as they relax to accommodate the coming blood from atria.
- Ventricular volume: increase.
- Aortic pressure: decrease (to 80 mmHg) the diastolic pressure.





Events of the cardiac cycle for left ventricular function, showing changes in left atrial pressure, left ventricular pressure, aortic pressure, ventricular volume, the electrocardiogram, and the phonocardiogram. A-V, Atrioventricular.

D. Atrial Diastole:

- Duration 0.7 sec.
- During this phase, atrial muscles relax and atrial pressure gradually increases due to the continuous venous return to drop to almost zero mmHg with the opening of 'A-V valves'.
- Then the pressure rises again during the phase of diastasis and follows the ventricular pressure.