Anatomy and Physiology

Cardiovascular System

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Cardiac Cycle

Definition

Cardiac Cycle is defined as Electrical, mechanical events and Volumatic changes that occur from Beginning of the one heart beat To the beginning of the next heart beat.

Calculation of duration of cardiac cycle

Duration of each cardiac cycle at a Normal heart rate of 72 beats/minute or 60 seconds / 72 beats = 0.8 sec

Phases of cardiac cycle

During each cardiac cycle

1. Atria contract (Atrial Systole) and
2. Atria Relax (Atrial Diastole)
3. Ventricles Contract (Ventricular Systole)
4. Ventricles Relax (Ventricular Diastole)

Atrial cycle

Atrial Cycle total duration (0.8 sec)

Atrial Systole or Contraction Phase (0.1 sec)

Atrial Diastole or Relaxation Phase (0.7 sec)

Ventricular cycle

Ventricular Cycle (0.8sec)

Ventricular systole (0.3 sec) consisting of

1. Isovolumic (Isometric) Contraction Phase (0.05 sec)
2. Phase of ventricular ejection (0.25 sec)
    a. Rapid ejection phase (0.1 sec)
    b. Slow ejection phase (0.15 sec)

Ventricular diastole (0.5 sec) consisting of

1. Protodiastole (0.04 sec)
2. Isovolumic (Isometric) relaxation phase (0.06 sec)
3. Rapid passive filling phase (0.11 sec)
4. Reduced filling phase or Diastasis (0.19 sec)
5. Last rapid filling phase which coincides with atrial systole (0.1s)

Atrial Cycle (0.8 sec)

1. Atrial Systole or Contraction Phase (0.1 sec)
2. Atrial Diastole or Relaxation Phase (0.7 sec)

Atrial Systole (0.1sec)

Atrial contraction phase which lasts for 0.1 sec and Coincide with the last rapid filling phase of ventricular diastole.

Before beginning of the atrial systole, the ventricles are relaxing (Ventricles Diastole). AV valves are open & blood is flowing From the Great veins in to Atria and From the Atria in to Ventricles Thus Atria and Ventricles are forming a continues cavity. When the Atrial contraction begins About 75 % of the blood already flown in to the ventricles Thus atrial contraction usually causes an additional 25 % filling of the ventricles

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Thus, atrial contraction usually causes the remaining 25 % filling of the ventricles.

Pressure changes during cardiac cycle

Pressure changes during atrial systole

Contraction of the atria causes increase in Intra Atrial Pressure By 4-6 mmHg in Right atria and 7-8 mmHg in left atria.

Pressure rises in Right Atrium, the pressure rise in Right atrium (4-6 mmHg), Is reflected into the veins and is recorded as “a” wave from the Jugular vein.

Atrial systole will Increase Intraventricular Pressure, increase in the ventricular pressure occurs slightly due to Pumping of blood in the ventricles. Contraction of the atria causes, narrowing of origin of the great veins’ Inferior vena cava & superior vena cava opening IVC & SVC In Right atrium Pulmonary vein opening in the Left atrium.

Atrial diastole

After the Atrial systole There occurs Atrial diastole (0.7 sec). Coincide with The Ventricular systole And Most of the Ventricular diastole. During atrial diastole, Atrial muscles Relax, Gradual filling of the atria occurs due to continuous venous return SVC, IVC, Right Atria, Pulmonary vein, Left atria.

Pressure Changes during Atrial Diastole

Pressure gradually increase, then drop down to zero when the opening of the AV valves.

Atrial Diastole-0.7sec

The pressure again rises then follows the Ventricular pressure, during the rest of the atrial diastole.

Ventricular Cycle (0.8 sec)

After the atrial contraction is over, the ventricles start contracting the ventricles get excited by the impulse travelling along the conduction system.

Ventricular Systole (0.3 sec)
Consisting of

1. Isovolumic (Isometric) Contraction Phase (0.05 sec)
2. Phase of ventricular ejection (0.25 sec)
    a. Rapid ejection phase (0.1 sec)
    b. Slow ejection phase (0.15 sec)

Phase of Isovolumic Contraction (0.05 sec)
With the beginning of the ventricular contraction,
Ventricular pressure exceeds the Atrial pressure very rapidly causing closer of the AV Valves.
This event Is responsible for the production of the First Heart Sound (Closure of AV valves).

Beginning of Isovolumic contraction phase, since AV Valves are closed and semilunar Valves have not opened So the ventricles contract as a closed chamber the pressure inside the ventricles rises rapidly to the high level called Phase of Isovolumic Contraction (0.05sec)
As the ventricles contract and the volume of the blood in the ventricle does not change, so this phase is also called Isovolumic Contraction Phase.

During this phase due to sharp rise in the ventricular pressure there occurs Bulging of the AV valves in the atria producing a small but sharp rise in the Intra Atrial Pressure Curve called C-wave.

This phase lasts for 0.05 sec, until the Pressure in the Left ventricle xceeed the pressure in the Aorta (80 mmHg), Results Aortic valve open.

Phase of ventricular ejection(0.25 sec)

Begins with the opening of The Semilunar valves, Aortic and Pulmonary Valves Lasts for the about 0.25 sec.

Further divided in to the two phases:

1. Rapid ejection phase (0.1sec)
2. Slow ejection phase (0.15sec)

(0.1 + 0.15 = 0.25 sec)

Rapid Ejection Phase (0.1sec)

As soon as the semilunar valves open the blood is rapidly ejected out for about 0.1 sec two third (2/3rd) of the stroke volume (SV) Is ejected in this phase.

Pressure rises to about 120 mmHg in the Left ventricle and to 25 mmHg in the Right ventricle

Slow Ejection Phase (0.15 sec)

Later 2/3 rd of the systole (0.15 sec), rate of ejection declines, About 1/3rd of the stroke volume is ejected during this phase

Volume Changes in Ventricle

1. Stroke Volume (SV)
2. End-systolic Volume (ESV)
3. End-diastolic volume (EDV)

End-Diastolic Volume (130mL)- At the end of each diastole (Ventricular Relaxation) The ventricular volume is about 130 ml called end-diastolic Volume (EDV).

Stroke Volume (80mL) - About 80 mL of the blood is ejected out by each ventricle during each systole called Stroke Volume.

End-Systolic Volume (130 – 80 mL) About 50 ml of the blood ss left in the each ventricle at the end of each systole is called End-systolic Volume.

Ventricular Diastole (0.5 sec)

Ventricular diastole (0.5 sec) consisting of

1. Protodiastole 0.04 sec
2. Isovolumic (Isometric) relaxation phase 0.06 sec
3. Rapid passive filling phase 0.11 sec
4. Reduced filling phase or Diastasis 0.19 sec
5. Last rapid filling phase which coincides with atrial systole: 0.1sec

Protodiastole (0.04 sec)

When the ventricular systole ends, the ventricles start relaxing Protodiastole phase lasts for the0.04 sec.

Intra Ventricular Pressure falls rapidly. During this phase Elevated pressure in the distended arteries (Aorta And Pulmonary) immediately pushes the blood back towards ventricles Which snaps the Semilunar Valves to Close.

Closure of Semilunar valves Aortic valve & Pulmonary valve produces Second (2nd) Heart Sound.

Isovolumic Relaxation phase(0.06sec)

This phase begins with the closure of the semilunar valves and lasts for about 0.06 sec.

Since Semilunar valves (Aortic & Pulmonary) closed and the AV valves are not yet opened so the ventricles continue to relax as the closed chambers.

In this phase the ventricular volume remains same and constant so this phase is called the IIsometric (Isovolumic) relaxation phase

This phase Ends with the AV valves open as indicated by the peak of the V wave on the Atrial pressure tracing

Rapid passive filling phase (0.11 sec)

During ventricular systole, the atria are in diastole and Venous return continues in Atria so that are atrial pressure is high than Ventricular.

When the AV valves open.

Rapid passive filling phase (0.11 sec)

The high atrial pressure causes rapid, initial flow of the blood in to ventricles and produces Third (3rd) heart sound

Rapid, initial flow of the blood in to ventricles

Reduce Filling Phase/Diastasis (0.19 sec)

In this phase, the Pressure in the Atria and Ventricles reduces slowly and remains little above zero (0)

This decreases the rate of blood flow from atria to ventricle causing a very slow filling or virtually cessation of ventricular filling called iastasis

Last rapid filling phase(0.1sec)

75% of the blood passes from the atria to ventricles, during the *Rapid* filling phase and reduce filling phase of ventricular diastole coincide with the atrial systole and pushes additional 25% of the filling of the blood in the ventricles with this phase the ventricular systole ends.