PHYSIOLOGY TEAM 435

جامعة الملك سعود
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Physiology
OF THE CARDIOVASCULAR SYSTEM

Cardiac Cycle

I & II

Cardiac Cycle

- Mechanical Events
- Volume Changes
- Pressure Changes
- Hearts Sounds
- Electrical Events [ECG] (Next Lecture)

-Mechanical Events Periods:
Ventricular systole = 0.3sec
Ventricular diastole = 0.5sec
Atrial systole = 0.1sec
Atrial diastole = 0.7sec

-Intra-Cardiac Pressures:
Right Atrium: 2-8 mmHg
Right Ventricle: 25-30/2-8 mmHg
Aorta: 120/80 mmHg
Left Atrium: 2-10 mmHg
Left Ventricle: 120/3-12 mmHg
Pulmonary Artery: 25-30/4-12 mmHg

-Mechanical Phases:
-Ventricular Systole :
1.Isometric contraction phase.
2.Rapid ejection phase.
3.Reduced ejection phase.
-Ventricular diastole:
Early ventricular diastole:
1.Isometric relaxation.
2.Rapid filling phase.
Mid ventricular diastole:
3.Reduced filling phase.
Late ventricular diastole:
4.Atrial systole

Phases	Ventricular Volume
1. Atrial Systole	⇧
2. Isometric contraction phase	Constant
3. Rapid ejection phase	⇩ Rapidly
4. Reduced ejection phase	⇩ Slowly
?. Protodiastole	Constant
5. Isometric relaxation phase	Constant
6. Rapid filling phase	⇧ Rapidly
7. Reduced filling phase	⇧ Slowly

Ventricular Pressure

Aortic Pressure
a. Ascending or anacrotic limb: up to 120 mmHg.
b. Descending or catacrotic limb:
1. Aortic press: With 'reduced ejection phase.'
2. Dicrotic notch (ncisura): Due to closure of aortic-v. Sudden drop in aortic pressure. At end of ventricular systole.
3. Dicrotic wave: Due to elastic recoil of the aorta. Slight ascend in aortic pressure.
4. Slow descending aortic press: up to 80 mmHg.

Atrial Pressure
Results in:
-3 upward deflection:a, c, & v
-2 downward deflection: x &y
*The 3 wave (a, c, & v) are equal to ONE cardiac cycle = 0.8 sec

	S1	S2	S3	S4
Due to	closure of the AV- vs	closure of semilunar- vs		
Recorded	at the beginning of the 'isovolumetric contraction phase'	at the beginning of the 'isovolumetric relaxation phase'	during the 'rapid filling phase' due to rush of blood into the ventricle	during 'atrial systole'
Marks	the beginning of ventricular systole	the beginning of ventricular diastole.		
Duration	Long in duration: 0.15 sec	Short in duration: 0.11-0.125 sec	0.05 sec	0.05 sec
Pitch	low pitch (LUB), Loud	high pitch (DUB), Soft & Sharp	usually not audible (very low pitch)	usually not audible (very low pitch)
Frequency	25-35 Hz	50 Hz		
Best Heard	at Mitral & Tricuspid areas	at Aortic & Pulmonary areas	at Mitral area	at Mitral area
Notes		S2 splits physiologically into 2 sounds during inspiration = Physiological Splitting, it occurs due to delay closure of pulmonary valve.	heard in children	heard in elderly

	Atrial Systole	Isovolumetric Contraction Phase:	Maximum (Rapid) Ejection Phase	Reduced Ejection Phase	Isovolumetric Relaxation Phase	Rapid Filling Phase	Reduced Filling Phase (Diastasis)
Occurs	At end of ventricular diastole	At beginning of ventricular systole		End of systole	Beginning of diastole		
Duration	lasts 0.1 sec	Lasts ≈ 0.04 sec			Lasts ≈ 0.04 sec.		
Preceded by	atrial depolarization	ventricular depolarization			ventricular repolarization		
Valves:	AV- vs open (semilunar- vs closed.)	Starts with closure of AV- vs.	Semilunar- vs open at beginning of this phase When LV pressure exceeds 80 mmHg	Aortic- v closes at the end of this phase when LV pressure reaches 110 mmHg.	Period between closure of semilunar- vs & opening of AV- vs	AV- vs open.	AV- vs still open
Volume changes	Tops off last 27-30% of ventricular filling	Volume in ventricle = EDV Ventricle contracts with no changes in volume. Ventricular	Almost 75% of ventricular blood is ejected, i.e. 75% of SV	Almost 25% of ventricular blood is ejected, i.e. 25% of SV.	Volume of blood in ventricle = ESV	≈ 60-70% of blood passes passively to the ventricles along pressure gradient.	
Pressure changes	↑ Atrial pressure	↑ Aortic v opens at the end of this phase, when LV exceeds 80 mmHg.	Ventricular pressure reaches 120 mmHg.			Atrial pressure > ventricular pressure.	
Sounds	4th Heart sound heard	1st Heart sound heard			2nd Heart sound heard	3rd Heart sound heard.	
Notes	Blood arriving the heart can't enter atria, it flows back up jugular vein	Ventricle is a closed chamber			LV is a closed chamber, i.e. relax with no changes in volume.		Remaining atrial blood flows slowly into ventricles

Definitions:

End-diastolic volume (EDV):

- Volume of blood in ventricles at the end of diastole.
  ≈ 110-130 mL

Stroke volume (SV):

- Amount of blood ejected from ventricles during systole.
  ≈ 70 mL/beat.

End-systolic volume (ESV):

- Amount of blood left in ventricles at the end of systole.
  ≈ 40-60 mL

Ejection fraction (EF):

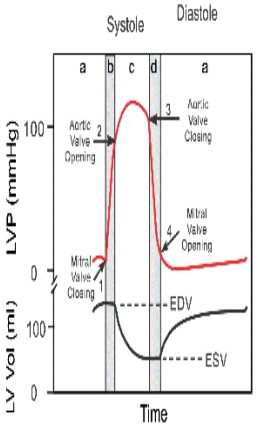
- Fraction of end-diastolic volume that is ejected.
  ≈ 60-65 %.

Cardiac Cycle- 2

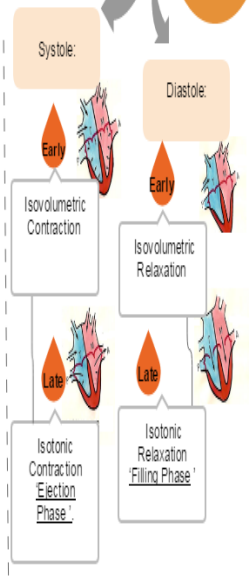
ECG

- P- Wave
  - Due to atrial depolarization.
  - P- wave is recorded before the onset of the atrial systole.
- QRS- Complex
  - Due to ventricular depolarizatio
  - QRS complex is recorded before the onset of ventricular systole (isometric contraction phase).
- T- Wave
  - Due to ventricular repolarization.
  - T- wave is recorded before the onset of ventricular diastole

Left Ventricular Pressure – Volume Curve



Left Ventricular Pressure – Volume Loop



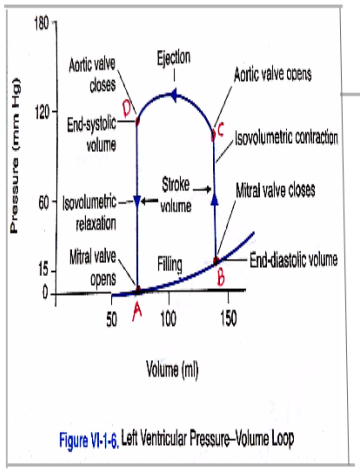


Figure VI-1-6. Left Ventricular Pressure–Volume Loop

NOTE

Closer & opening of mitral & aortic- vs during each phase.

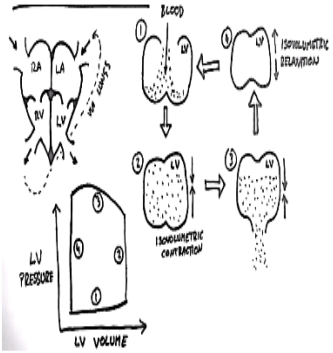
Beginning of systole (B) & end (D).

Beginning of diastole (D) & end (B.)
Early & late diastolic periods.

Diastolic filling occurs between points A & B.

Ejection occurs between points C & D.

SV = EDV - ESV



FOR THE CLEAR VERSION: https://www.gliffy.com/go/publish/image/10090403/L.png

Phases	Atrial systole	Isovolumetric contraction	Rapid ejection	Reduce ejection	Isovolumetric relaxation	Rapid filling	Reduce filling
Atrial contraction (systole) 0.1 sec	+	-	-	-	-	-	-
Ventricles contraction (systole) 0.3 sec	-	+	+	+	-	-	-
Atrial relaxation (diastole) 0.7sec	-	+	+	+	+	+	+
Ventricle relaxation (diastole) 0.5 sec	+	-	-	-	+	+	+

Phases	Atrial systole	Isovolumetric contraction	Rapid ejection	Reduce ejection	Isovolumetric relaxation	Rapid filling	Reduce filling
AV valve open	+	-	-	-	-	+	+
AV valve closure	-	+	+	+	+	-	-
Semilunar valve open	-	-	+	+	-	-	-
Semilunar valve closure	+	+	-	-	+	+	+

Sounds	S1	S2	S3	S4
Due to (cause)	Closure of AV valves	Closure of semilunar valves	Vibration produced Rush of the blood into ventricle	Vibration produced Atrial systole
Time	Long 0.14 sec	Short 0.11 sec	Short 0.05 s	Short 0.04 s
Frequency		Higher than S1		20 cycles/sec
Character	Low pitch Lub	High pitch Dub - physiological splitting in inspiration	- S3 is usually not audible (very low pitch) - Heard in children - Pathological sound	- S4 is usually not audible (very low pit.ch) - Heard in elderly - Pathological sound
In cardiac cycle	At The beginning of the ' isovolumetric contraction phase	At The beginning of the ' isovolumetric relaxation phase at the end of the systole	At the beginning of middle third of diastole During rapid filling phase	Last one third of diastole (before S1) During atrial systole
Best heard at	In mitral or tricuspid area (AV)	Aortic and pulmonary area (semilunar)	Mitral area	Mitral area
Other	- It marks the beginning of ventricular systole	- It marks the beginning of ventricular diastole - physiological splitting during inspiration due to delay closure of pulmonary valve.		