Cardiovascular Physiology

Cardiac Cycle- 1

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At end of this lecture you should be able to know:

- ✓ General principles of cardiac cycle
- ✓ Different events that occur during cardiac cycle: mechanical, electrical, volume/pressure changes & heart sounds
- ✓ Correlation of the different events that occur during cardiac cycle
- ✓ Various phases of mechanical events of cardiac cycle

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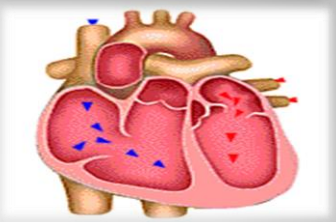
Cardiac Cycle ?

Sequence of events that takes place in the heart in each beat

- **I:** Mechanical events
- **II:** Volume changes
- **III:** Pressure changes
- **IV:** Heart sounds
- **V:** Electrical events (ECG)



- **Cardiac cycle duration = 0.8 sec …**
  - When HR 72 bpm
    - Shortened when HR ↑

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General Principles

- Contraction of the heart generates pressure changes, resulting in orderly blood movement
- Blood flows from an area of high pressure to an area of low pressure
- Heart is a double pump: right & left sides that work together
- Events in the right & left sides of the heart are the same, but with lower pressures in the right side

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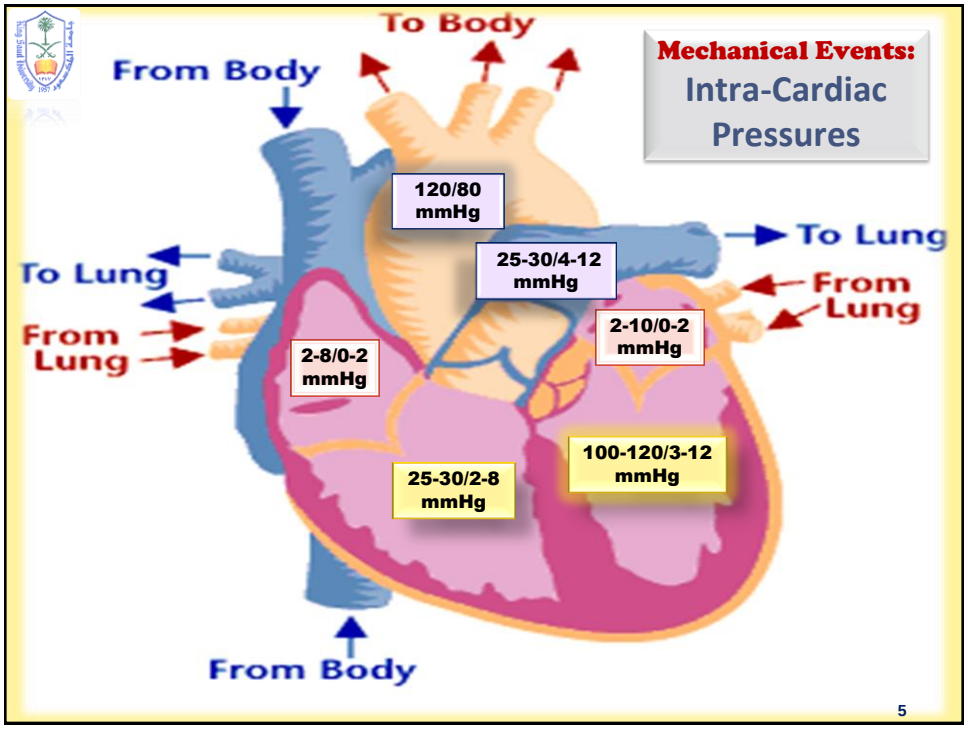

Definitions

- **End-diastolic volume (EDV):**
  - Volume of blood in ventricle at the end of diastole
  - ≈ 110-130 mL
- **Stroke volume (SV):**
  - Amount of blood ejected from ventricle during systole
  - ≈ 70 mL/beat
- **End-systolic volume (ESV):**
  - Amount of blood left in ventricle at the end of systole
  - ≈ 40-60 mL
- **Ejection fraction (EF):**
  - Fraction of end-diastolic volume that is ejected
  - ≈ 60-65 %

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Events in the cardiac cycle ?

I: **Mechanical events**

II: **Volume changes**

III: **Pressure changes**

IV: **Heart sounds**

V: **Electrical events (ECG)**

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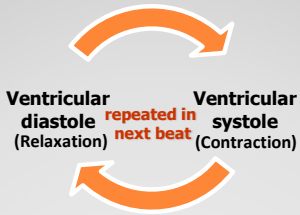
Mechanical Events:

- **Each heartbeat consists of 2 major periods:**
  - Systole (Contraction)
  - Diastole (Relaxation)



- **Atrial:** systole & diastole
- **Ventricular:** systole & diastole

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Mechanical Events' Periods:

- **Normally diastole is longer > systole:**
  - Ventricular systole = 0.3 sec
  - Ventricular diastole = 0.5 sec
  - Atrial systole = 0.1 sec
  - Atrial diastole = 0.7 sec
- **Importance of long ventricular diastole?**
  1. Coronary blood flow
  2. Ventricular filling

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Mechanical Events:
Mechanical Phases

Consists of 7 phases

- **Early ventricular diastole:**
  Protodiastole ????
  1. Isometric relaxation phase
  2. Rapid filling phase
- **Mid ventricular diastole:**
  3. Reduced filling phase
- **Late ventricular diastole:**
  4. Atrial systole

Ventricular diastole

Ventricular systole

- **Ventricular systole:**
  1. Isometric contraction phase
  2. Rapid ejection phase
  3. Reduced ejection phase

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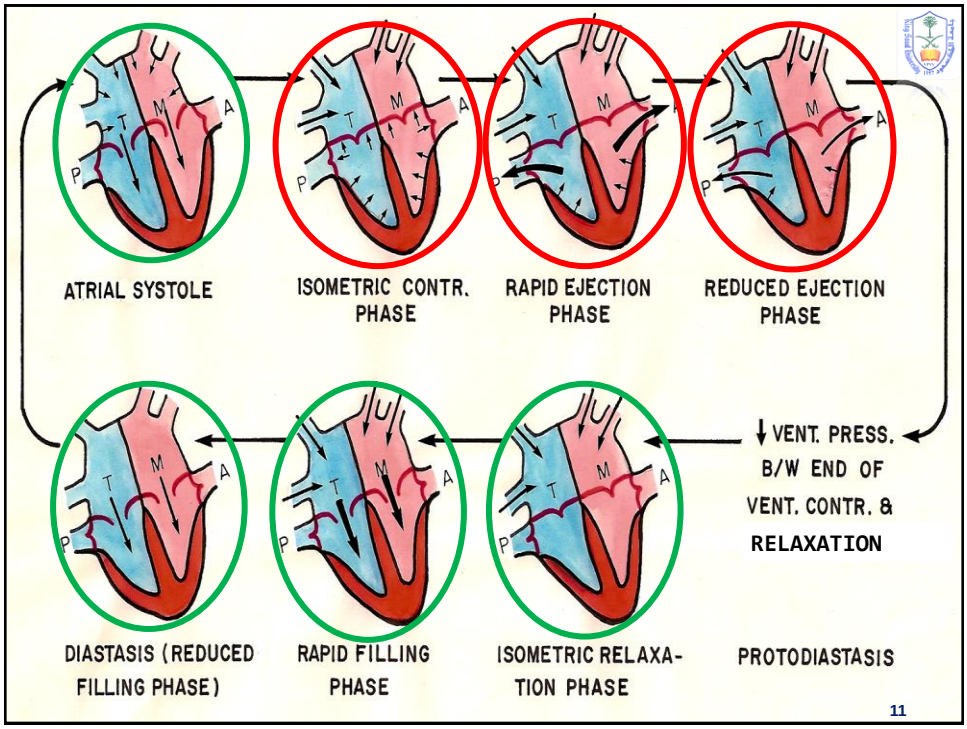
ATRIAL SYSTOLE
ISOMETRIC CONTR. PHASE
RAPID EJECTION PHASE
REDUCED EJECTION PHASE
VENT. PRESS. B/W END OF VENT. CONTR. & RELAXATION
PROTODIASTASIS
ISOMETRIC RELAXATION PHASE
RAPID FILLING PHASE
DIASTASIS (REDUCED FILLING PHASE)
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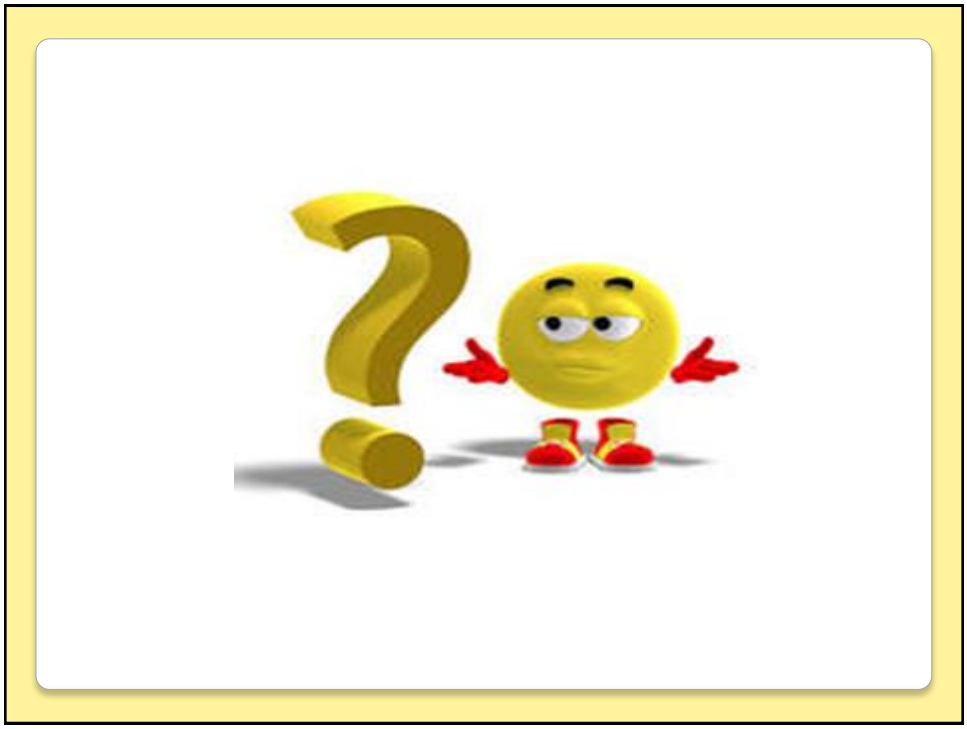

To Revise

To Revise:

- Blood flows from an area of [ ] pressure to an area of [ ] pressure
- Cardiac cycle duration is [ ] when HR = 72bpm
- Normally [ ] period is longer than [ ] period
- EDV ≈ [ ] mL
- SV ≈ [ ] mL/beat
- ESV ≈ [ ] mL
- EF ≈ [ ] %

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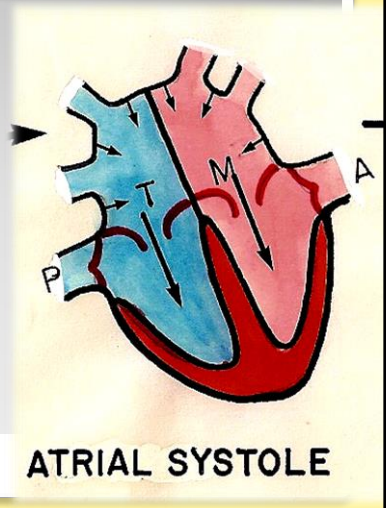
Mechanical Phases of cardiac cycle:

Atrial Systole:

- At the end of ventricular diastole … (lasts 0.1 sec)
- Preceded by atrial depolarization
- **Valves:**
  AV- vs open (semilunar- vs closed)
- **Volume changes:**
  Tops off last 27-30% of ventricular filling ≈ 40 mL
- **Pressure changes:**
  Atrial pressure ↑
- **4th Heart sound heard**
- Blood arriving the heart can't enter atria, it flows back up jugular vein



ATRIAL SYSTOLE

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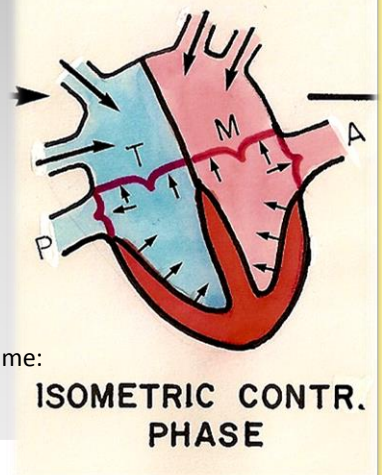
Mechanical Phases of cardiac cycle:

Isovolumetric Contraction Phase:

- At the beginning of systole … (0.04 sec)
- Period b/w closure of AV- vs & opening of Semilunar- vs
- Preceded by ventricular depolarization
- Starts with closure of AV- vs:
  - Ventricular pressure > atrial pressure
  - Atrial diastole
- **1st Heart sound heard**
- **Ventricle is a closed chamber:**
- Ventricle contracts w/out change in volume:
  - Volume in ventricle is the '**EDV**'
- Ventricular pressure < aortic pressure
  - Aortic v opens at the end of this phase: (when LV = 80 mmHg)



ISOMETRIC CONTR. PHASE

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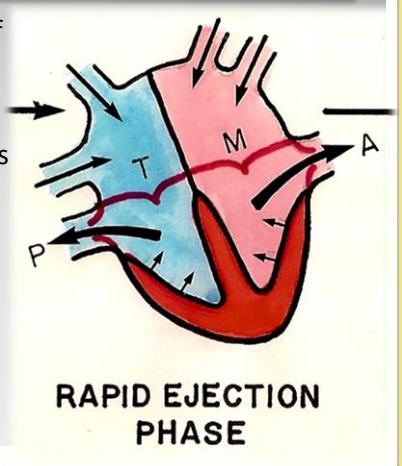
Mechanical Phases of cardiac cycle:

Maximum (Rapid) Ejection Phase:

- Semilunar- vs open at beginning of this phase:
  - when LV = 80 mmHg
- Contraction of the ventricle causes ventricular pressure > aortic pressure
- Almost 75% of ventricular blood is ejected:
  - Volume of ejected blood = **SV**
  - Ventricular volume ↓ rapidly
- Atrial diastole



RAPID EJECTION PHASE

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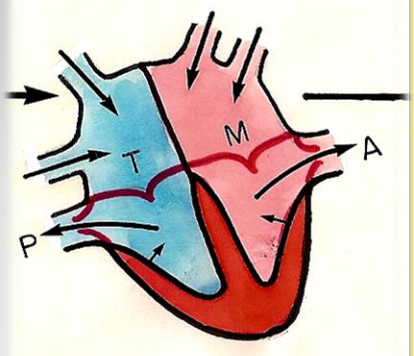
Mechanical Phases of cardiac cycle:

Reduced Ejection Phase:

- At the end of systole
- Almost 25% of ventricular blood is ejected:
  - Ventricular volume ↓ more slowly
- Aortic- v closes at the end of this phase, as a result of:
  - ↓ LV pressure 110 mmHg (Aortic back pressure)
- Atrial diastole



REDUCED EJECTION PHASE

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Mechanical Phases of cardiac cycle:

Protodiastolic Phase ????

- Period b/w end of ventricular systole & ventricular diastole
- Very short … (lasts 0.04 sec)
- Atrial diastole:
  - Atrial pressure still ↑, due to continuous VR

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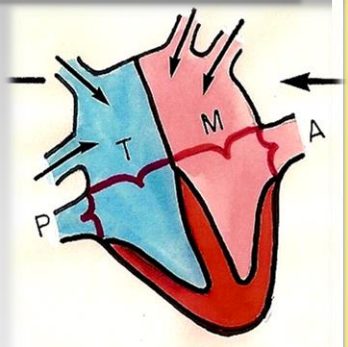
Mechanical Phases of cardiac cycle:

Isovolumetric Relaxation Phase:

- Quiescent period
- At beginning of diastole … (0.04 sec)
- Period b/w closure of semilunar- vs & opening of AV- vs
- Preceded by ventricular repolarization
- **2nd Heart sound heard**
- **LV is a closed chamber**, i.e. relax w/out change in volume:
  - Volume of blood in ventricle = **ESV**
  - LV relaxes with ↓↓ pressure
- AV- vs <u>open</u> at the end of this phase



ISOMETRIC RELAXA-TION PHASE

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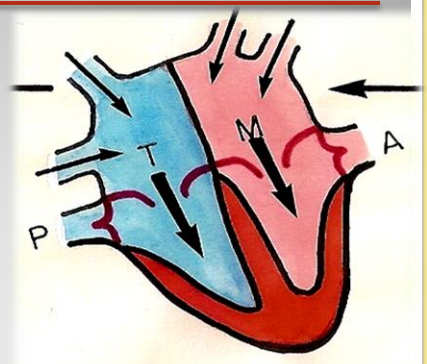
Mechanical Phases of cardiac cycle:

Rapid Filling Phase:

- Atrial pressure > ventricular pressure
- AV- vs <u>open</u>
- ≈ 60-70% of blood passes passively to the ventricles along pressure gradient:
  - Ventricular volume ↑ rapidly
- **3rd Heart sound heard**



RAPID FILLING PHASE

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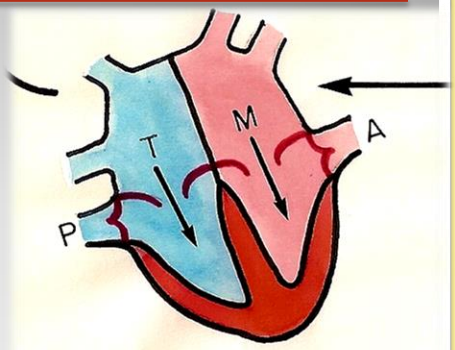
Mechanical Phases of cardiac cycle:

Reduced Filling Phase (Diastasis):

- Remaining atrial blood flows slowly into ventricles
- AV- vs still open
- LV volume ↑ > slowly



DIASTASIS (REDUCED FILLING PHASE)

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Thank You