

Major Elective-
BMS-EC-10
Cardiovascular Biology

CARDIAC CYCLE

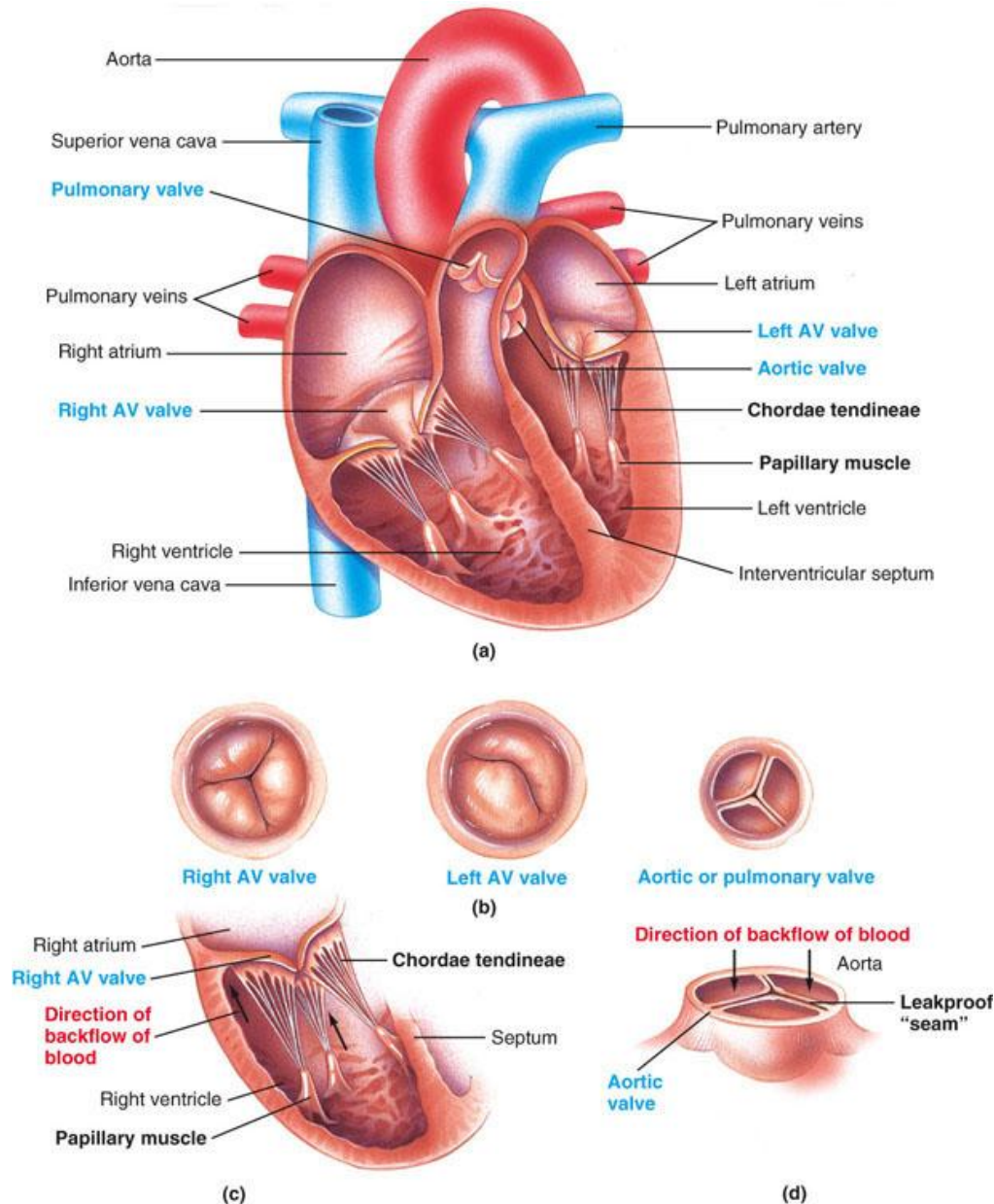
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Bharathidasan University

CARDIAC CYCLE

1. Heart is two pumps that work together, right and left half
2. Repetitive contraction (**systole**) and relaxation (**diastole**) of heart chambers
3. Blood moves through circulatory system from areas of higher to lower pressure.
 1. Contraction of heart produces the pressure

Cardiac Physiology - Anatomy Review



HEART VALVES

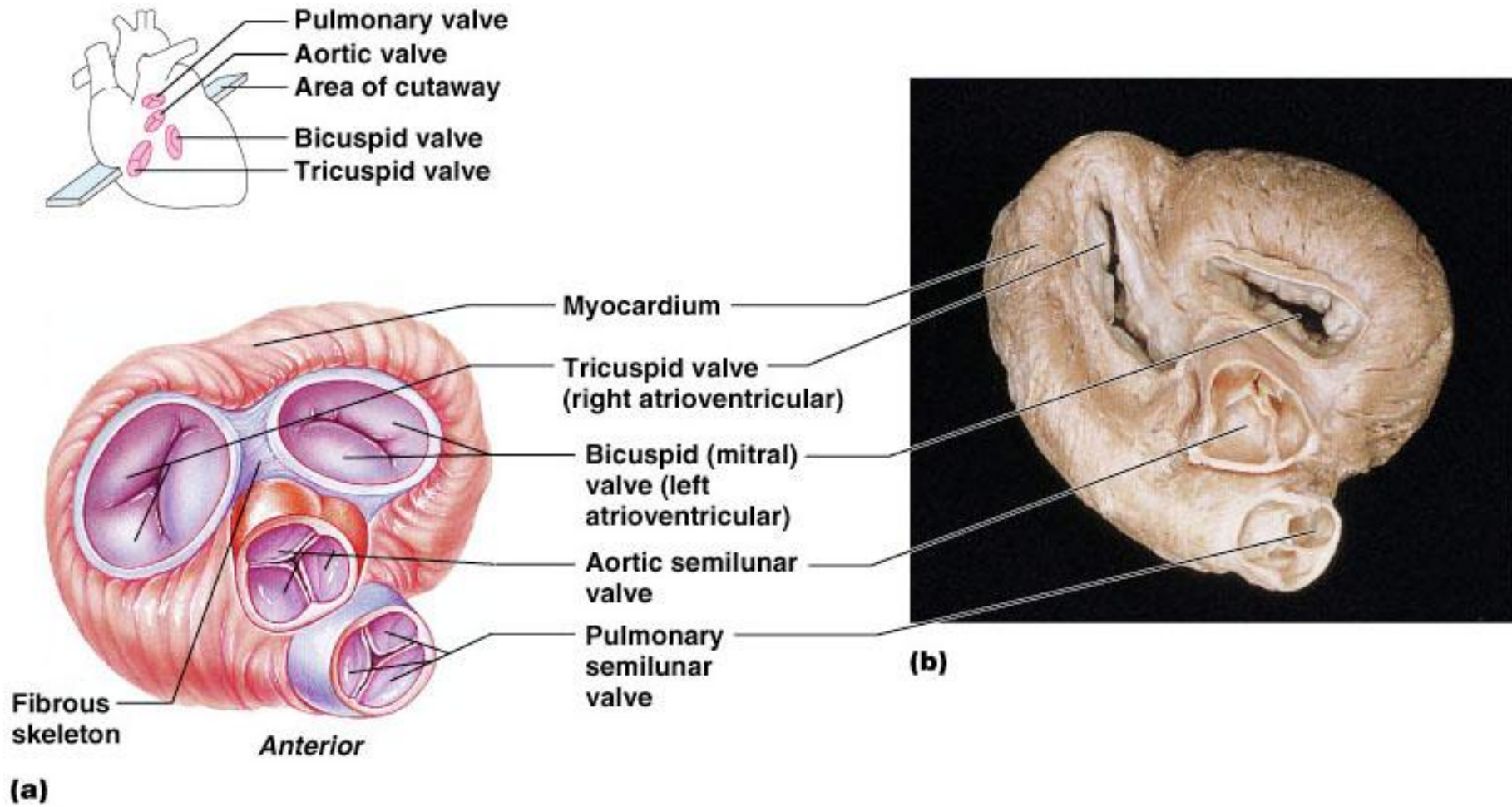
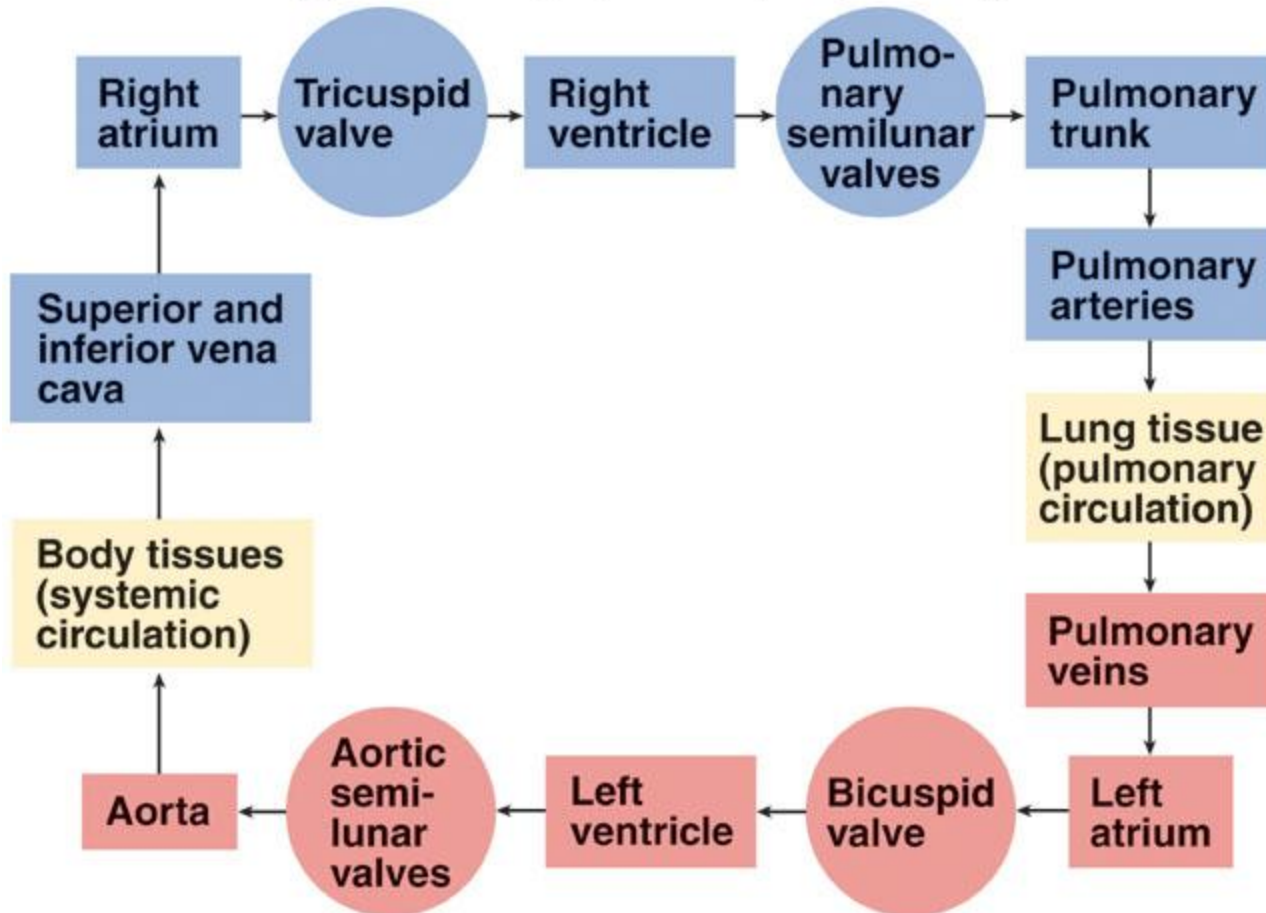


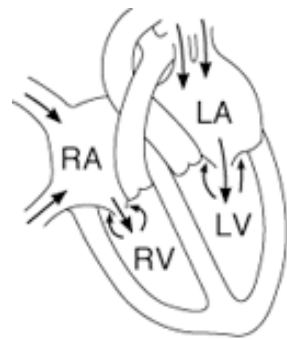
Figure 18.8a, b

Blood Flow Through Heart

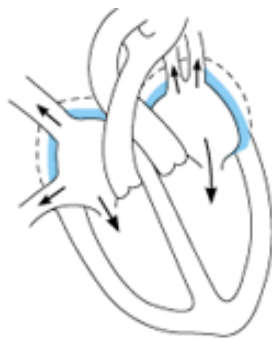
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CARDIAC CYCLE



Late diastole



Atrial systole



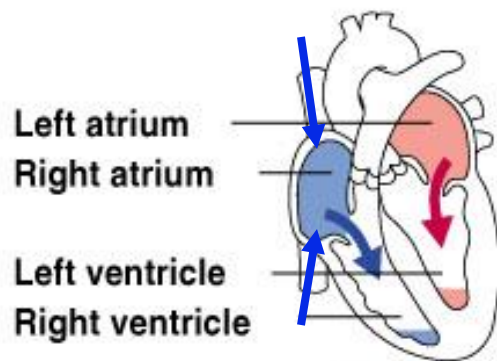
Isovolumetric ventricular contraction



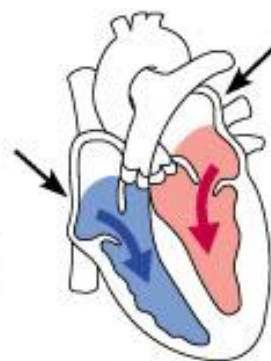
Ventricular ejection



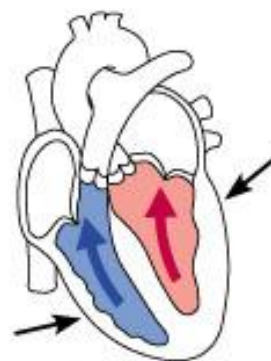
Isovolumetric ventricular relaxation



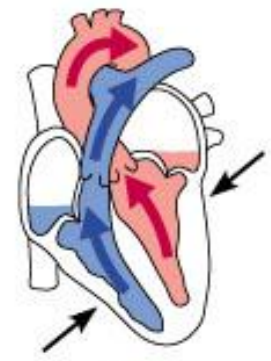
Ventricular filling



Atrial contraction



Isovolumetric contraction phase



Ventricular ejection phase

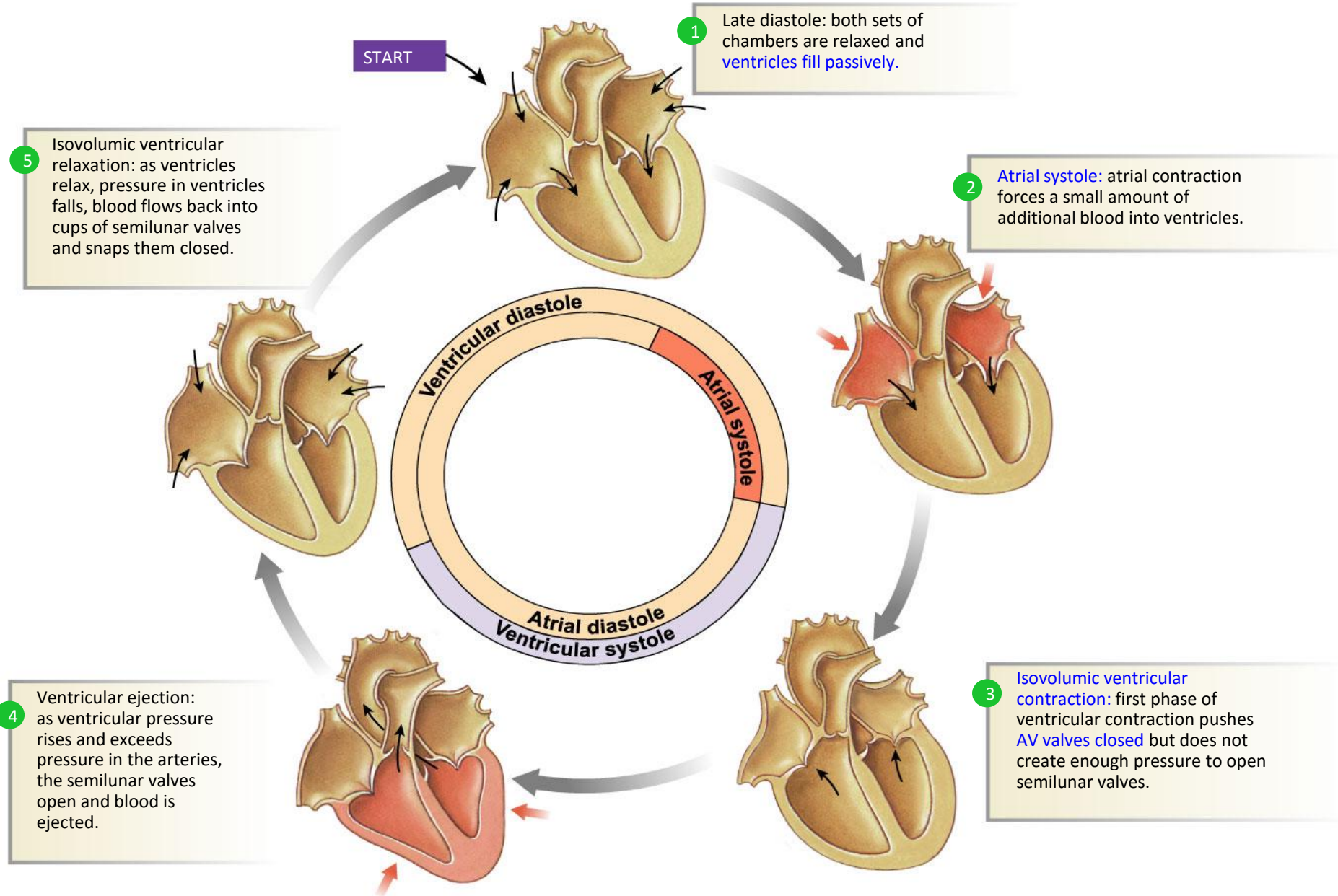


Isovolumetric relaxation

①
(Ventricular filling)
mid-to-late diastole

②
Ventricular systole
(atria in diastole)

③
Early diastole

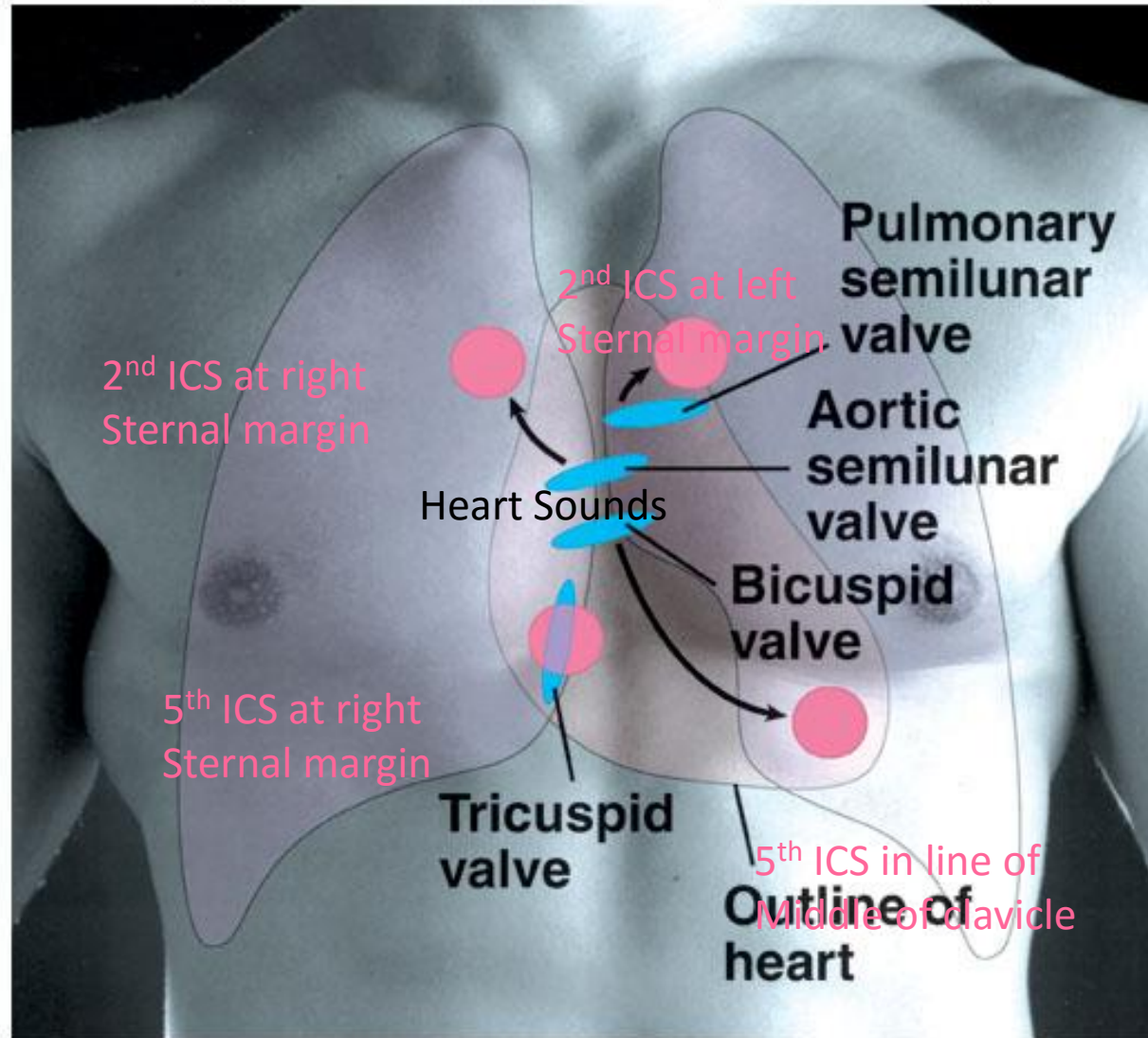


HEART SOUNDS

- **First heart sound or “lubb”**
 - Atrioventricular valves and surrounding fluid vibrations as valves close at beginning of ventricular systole
- **Second heart sound or “dupp”**
 - Results from closure of aortic and pulmonary semilunar valves at beginning of ventricular diastole, lasts longer
- **Third heart sound (occasional)**
 - Caused by turbulent blood flow into ventricles and detected near end of first one-third of diastole

Location of heart valves and heart sounds

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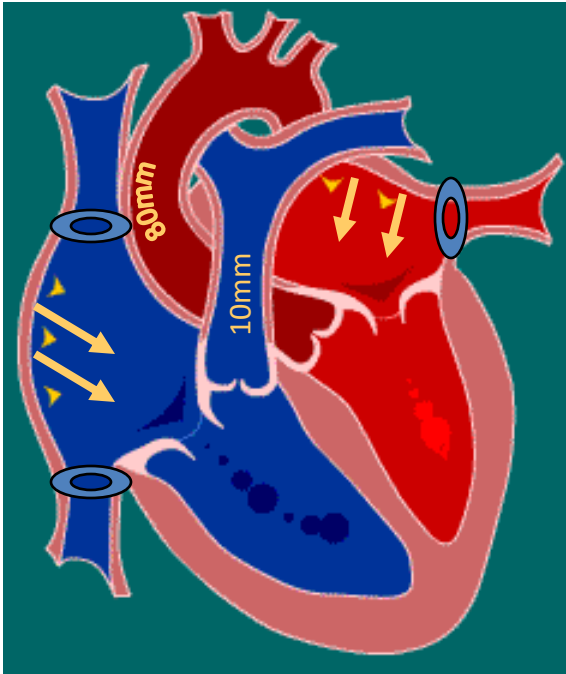


ATRIAL SYSTOLE

The end of diastole

ATRIAL SYSTOLE

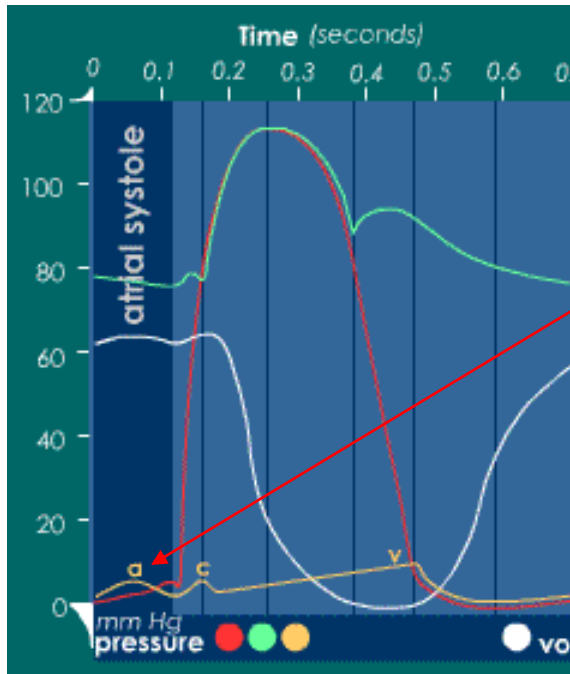
Heart



1. Atrial muscle that surrounds the orifices of the venae cavae and pulmonary veins narrows these orifices.
2. During atrial systole the atrium contracts and tops off the volume in the ventricle with only a small amount of blood(30%).
3. Atrial contraction is complete before the ventricle begins to contract.

ATRIAL SYSTOLE

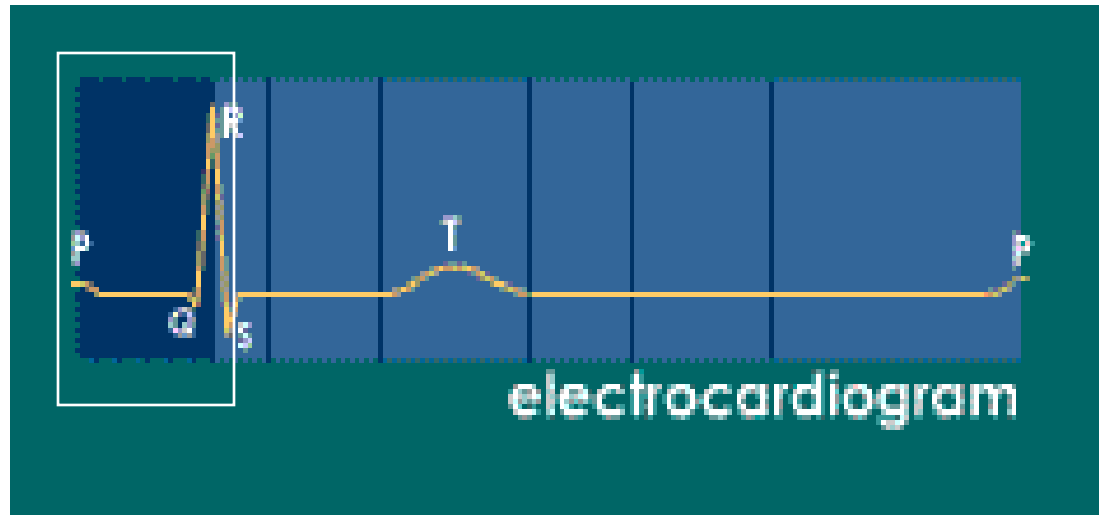
Pressures & Volumes



1. The "a" wave occurs when the atrium contracts, increasing atrial pressure (yellow).
2. Blood arriving at the heart cannot enter the atrium so it flows back up the jugular vein, causing the first discernible wave in the jugular venous pulse.
3. Atrial pressure drops when the atria stop contracting.

ATRIAL SYSTOLE

ECG



- An impulse arising from the SA node results in depolarization and contraction of the atria
- The P wave is due to this atrial depolarization.
- The PR segment is electrically quiet as the depolarization proceeds to the AV node.
- This brief pause before contraction allows the ventricles to fill completely with blood.

ATRIAL SYSTOLE

Heart Sounds

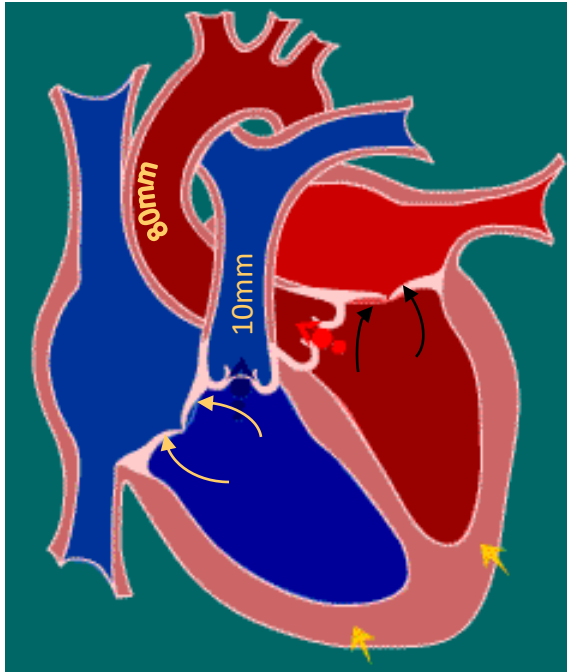


1. A fourth heart sound (S4) is abnormal and is associated with the end of atrial emptying after atrial contraction.
2. It occurs with **hypertrophic congestive heart failure**, massive pulmonary **embolism**, tricuspid incompetence, or cor pulmonale.

ISOVOLUMETRIC CONTRACTION

Heart

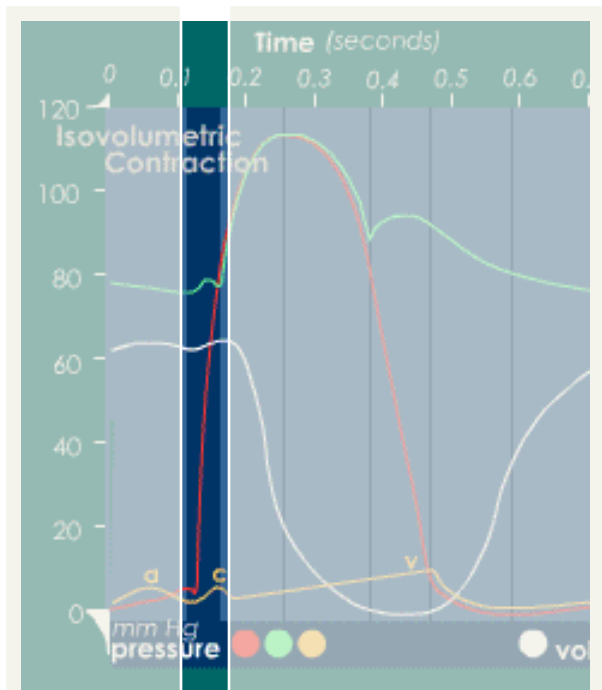
Ventricular systole



- The atrioventricular (AV) valves close.
- Ventricle muscle little bit shortens
- Ventricle pressure rises sharply
- **Electrically**, ventricular systole is defined as the interval between the QRS complex and the end of the T wave (the **Q-T interval**).
- **Mechanically**, ventricular systole is defined as the interval between the closing of the AV valves and the opening of the **semilunar valves** (aortic and pulmonary valves).

ISOVOLUMETRIC CONTRACTION

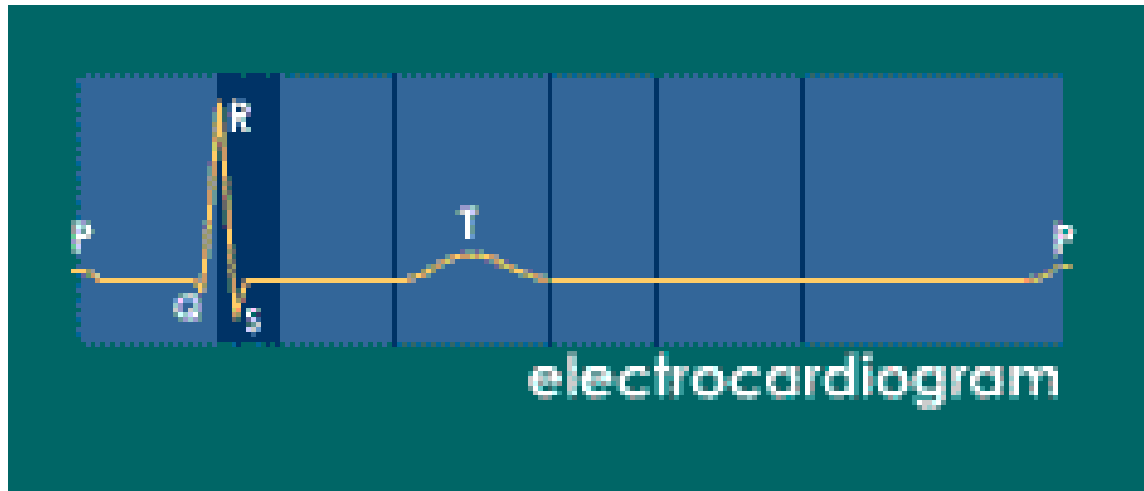
Pressures & Volumes



- The AV valves close when the pressure in the ventricles (red) exceeds the pressure in the atria (yellow).
- As the ventricles contract isovolumetrically -- their volume does not change (white) -- the pressure inside increases, approaching the pressure in the aorta and pulmonary arteries (green).

ISOVOLUMETRIC CONTRACTION

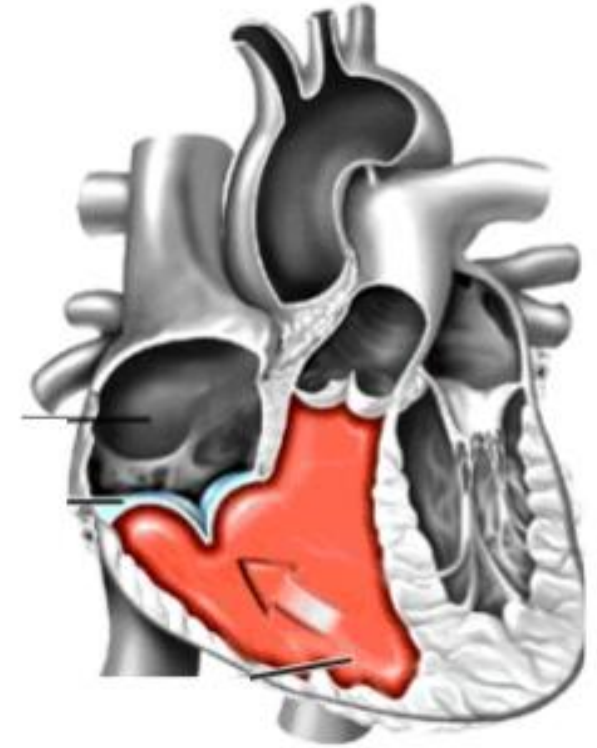
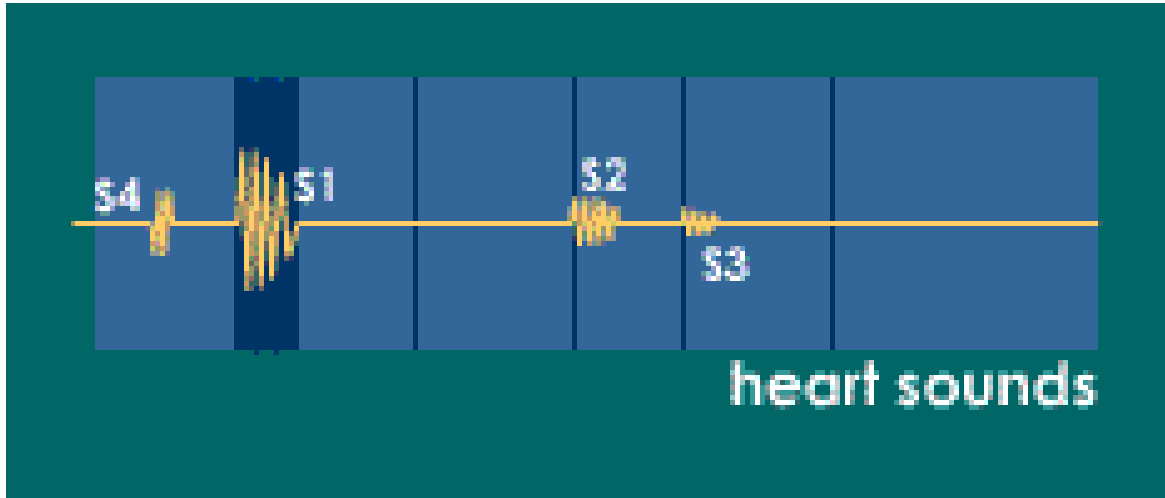
ECG



- The electrical impulse propagates from the AV node through the His bundle and Purkinje system to allow the ventricles to contract from the apex of the heart towards the base.
- The QRS complex is due to **ventricular depolarization**, and it marks the beginning of ventricular systole. The ventricles to fill completely with blood.

ISOVOLUMETRIC CONTRACTION

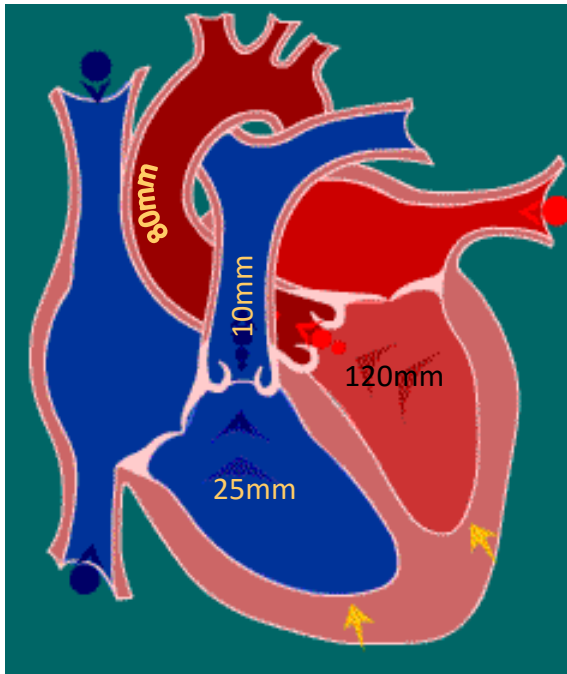
Heart Sounds



- The first heart sound (S1, "lub") is due to the closing AV valves at the beginning of ventricular contraction and associated blood turbulence.
- 1st sound is louder, longer, more resonant than the 2nd heard sound.

Ventricular (rapid) Ejection

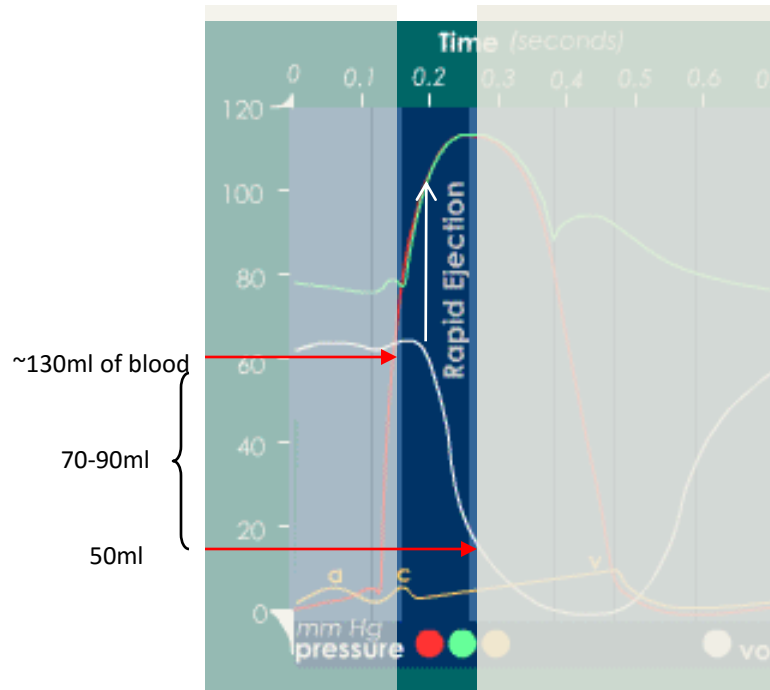
Heart



- The semilunar (aortic and pulmonary) **valves open** at the beginning of this phase.
- Ejection is rapid at first
- Slow down as progresses

REDUCED EJECTION

Pressures & Volumes



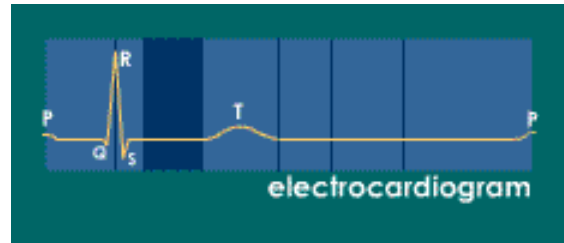
- While the ventricles continue contracting, the pressure in the ventricles (red) peaks and exceeds the pressure in the aorta and pulmonary arteries (green); blood exits the ventricles, and the volume in the ventricles decreases rapidly (white).
- As more blood enters the arteries, pressure there builds until the flow of blood reaches a peak.
- The amount of blood ejected by ventricle per stroke is 70-90ml.

Left ventricle pressure is 120mmHg
Right ventricle pressure is 25mmHg

REDUCED EJECTION

ECG

- No Deflections



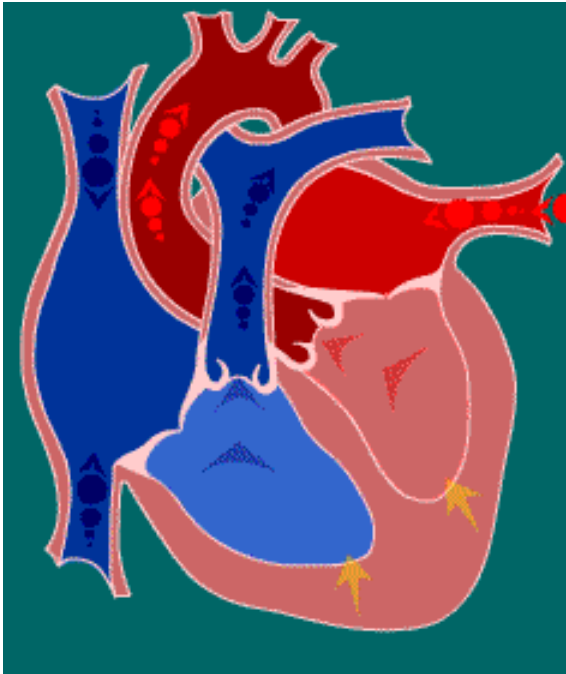
Heart Sounds

- None



REDUCED EJECTION

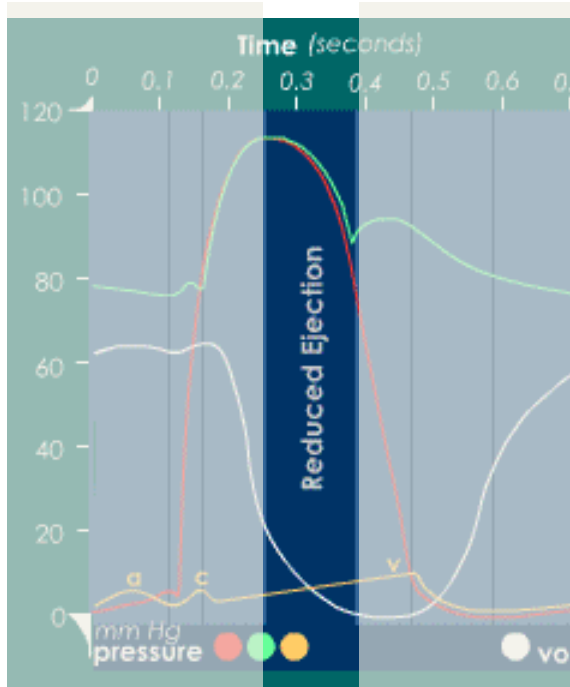
Heart



- At the end of this phase the semilunar (aortic and pulmonary) valves close.

REDUCED EJECTION

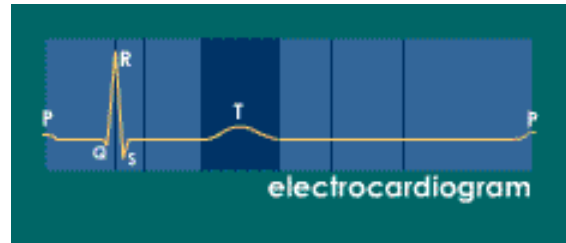
Pressures & Volumes



- After the peak in ventricular and aorta and pulmonary pressures (red and green), blood flow out of the ventricles decreases and ventricular volume decreases more slowly (white).
- When the pressure in the ventricles falls below the pressure in the arteries, blood in the arteries begins to flow back toward the ventricles and causes the semilunar valves to close. This marks the end of ventricular systole mechanically.

REDUCED EJECTION

ECG



- The T wave is due to ventricular repolarization. The end of the T wave marks the end of ventricular systole electrically.

Heart Sounds



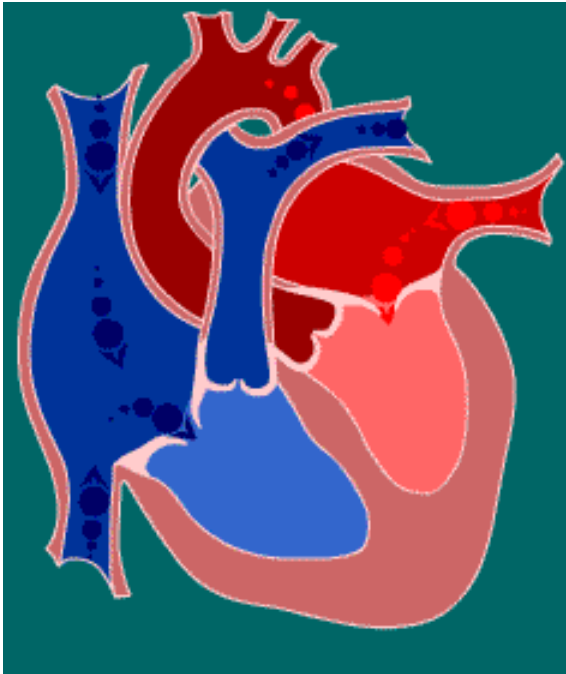
- None

ISOVOLUMETRIC RELAXATION

**The beginning of Diastole
Or
Early Diastole**

ISOVOLUMETRIC RELAXATION

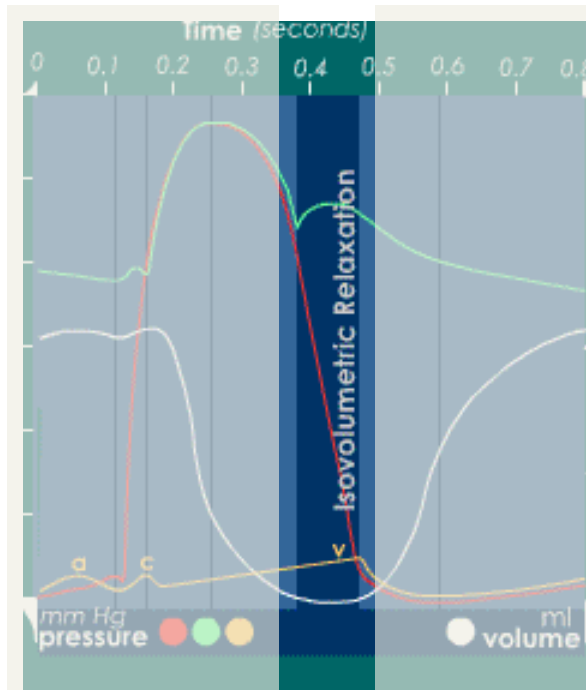
Heart



- At the beginning of this phase the AV valves are closed.

ISOVOLUMETRIC RELAXATION

Pressures & Volumes

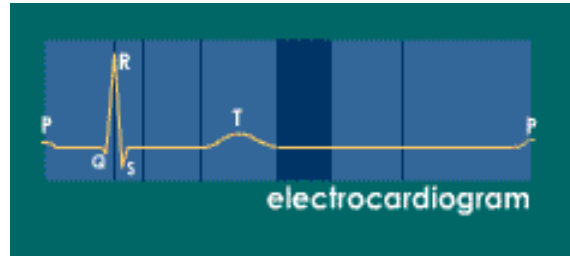


- Throughout this and the previous two phases, the atrium in diastole has been filling with blood on top of the closed AV valve, causing atrial pressure to rise gradually (yellow).
- The "v" wave is due to the back flow of blood after it hits the closed AV valve. It is the second discernible wave of the jugular venous pulse.
- The pressure in the ventricles (red) continues to drop.
- Ventricular volume (white) is at a minimum and is ready to be filled again with blood.

ISOVOLUMETRIC RELAXATION

ECG

- No Deflections

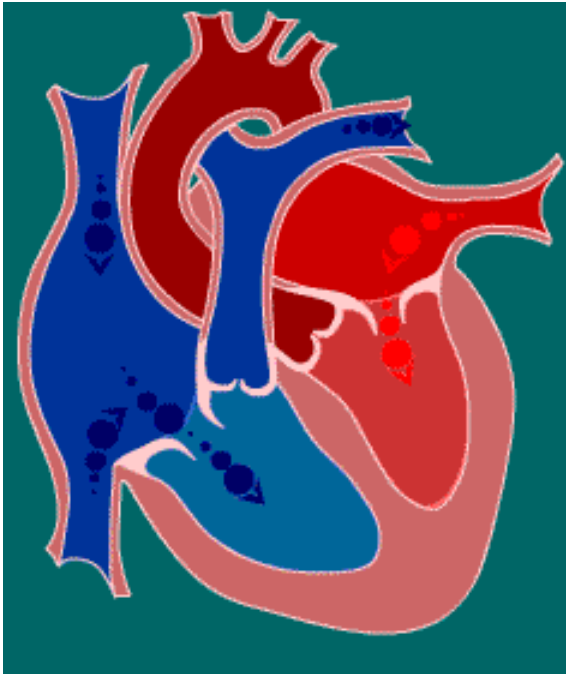


- The second heart sound (S2, "dup") occurs when the semilunar (aortic and pulmonary) valves close at the beginning of ventricular diastole. S2 is normally split because the aortic valve closes slightly earlier than the pulmonary valve.

EARLY DIASTOLE

RAPID VENTRICULAR FILLING

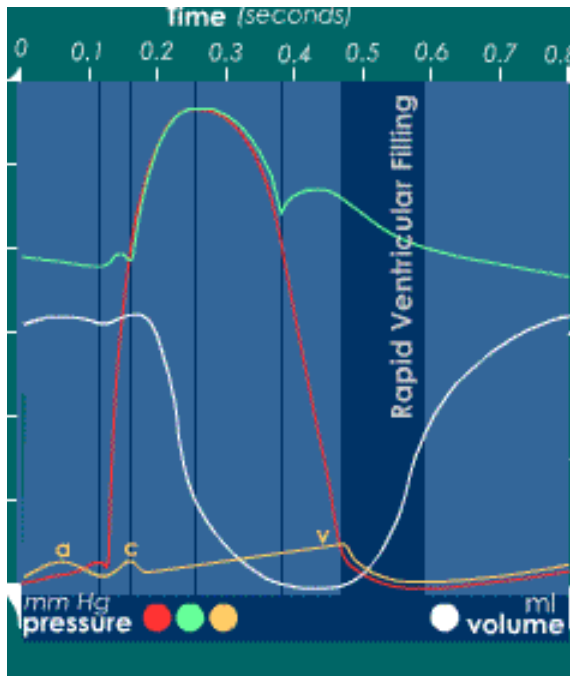
Heart



- Once the AV valves open, blood that has accumulated in the atria flows rapidly into the ventricles.

RAPID VENTRICULAR FILLING

Pressures & Volumes

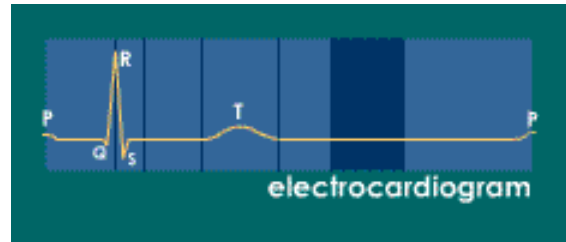


- Ventricular volume (white) increases rapidly as blood flows from the atria into the ventricles.

RAPID VENTRICULAR FILLING

ECG

- No Deflections



Heart Sounds



This can be recorded via Phonocardiography.

- A third heart sound (S3) is usually abnormal and is due to rapid passive ventricular filling. It occurs in dilated congestive heart failure, severe hypertension, myocardial infarction, or mitral incompetence.

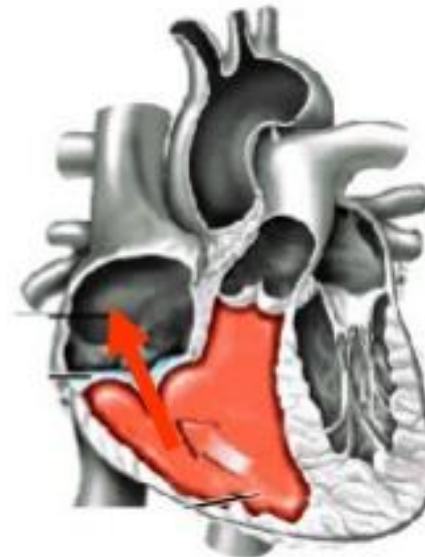
Two Basic Types of Valvular Disease

Two Basic Types of Valvular Diseases

1) **valvular stenosis**, a narrowing of the valve



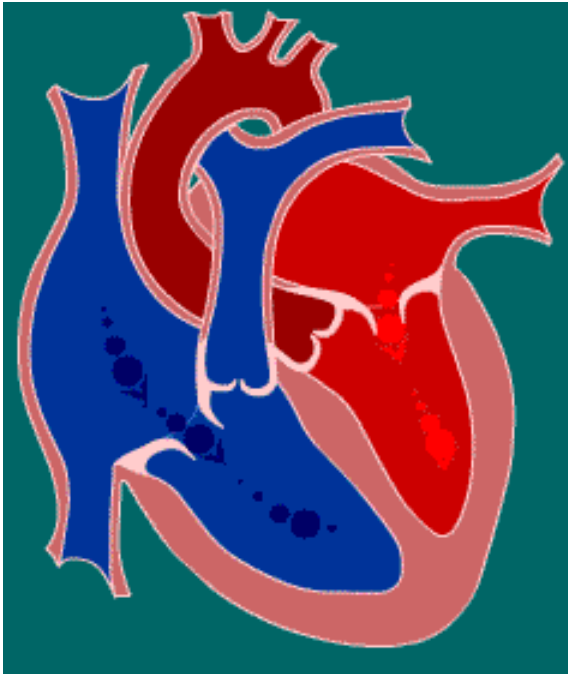
2) **valvular insufficiency** (incompetence). A valve is unable to close fully; so there is some backflow (regurgitation) of blood.



REDUCED VENTRICULAR FILLING (Diastasis)

REDUCED VENTRICULAR FILLING

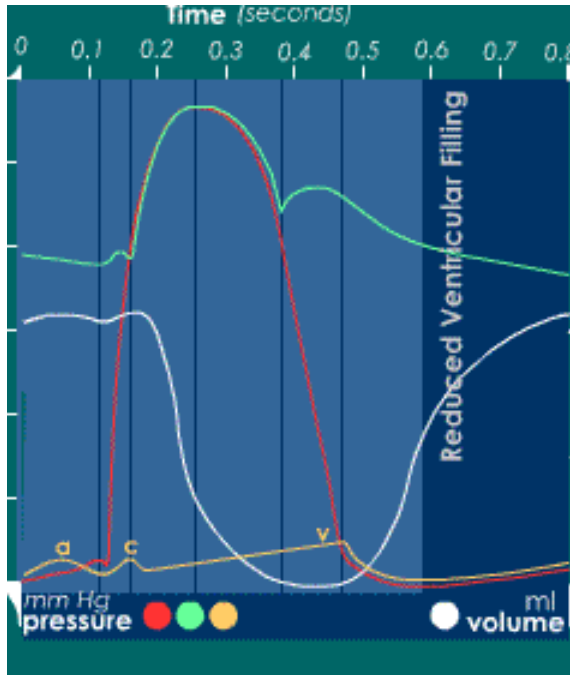
Heart



- Rest of blood that has accumulated in the atria flows slowly into the ventricles.

REDUCED VENTRICULAR FILLING

Pressures & Volumes

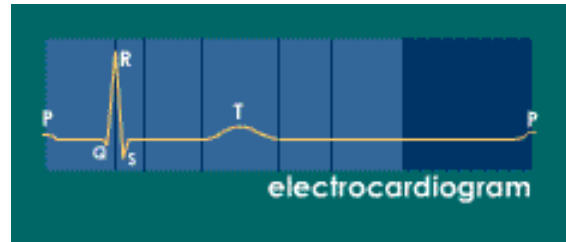


- Ventricular volume (white) increases more slowly now. The ventricles continue to fill with blood until they are nearly full.

REDUCED VENTRICULAR FILLING

ECG

- No Deflections



Heart Sounds

- None



CARDIAC CYCLE

Timing

Timing of the heart is somewhat asynchronous.

1. Right atrial systole goes **before** left atrial systole.
2. Right ventricular contraction start **after** the left ventricular .

Timing (ventricular)

3. Right ventricular ejection begins **before** left ventricles
4. During expiration pulmonary and aortic valves close at same time.
5. During Inspiration aorta valve closes before the pulmonary valve.

Pressure Volume cycle of Human left Ventricle

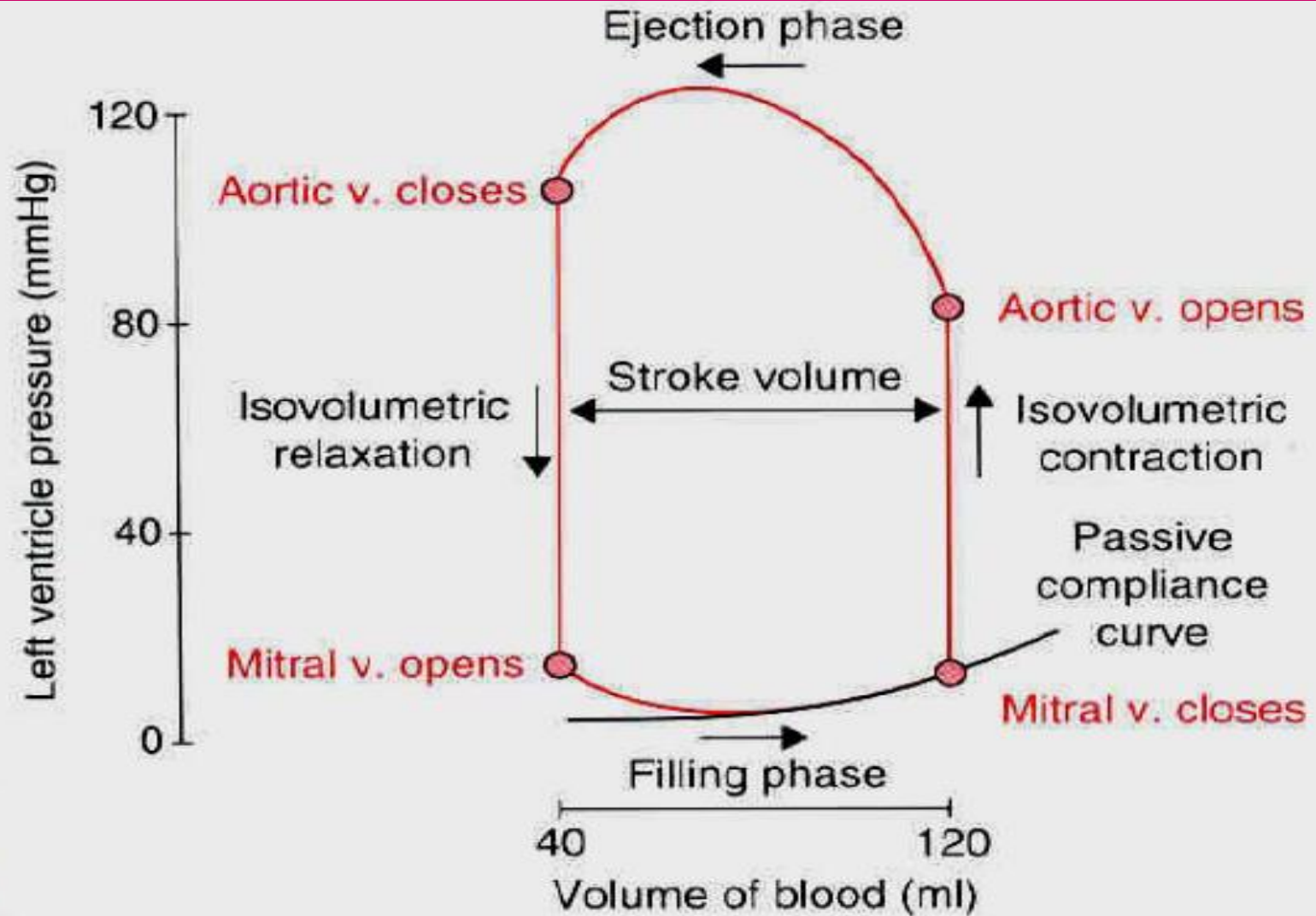


Figure 2.6 Pressure–volume cycle of human left ventricle.