Cardiac Cycle

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Cardiac Cycle

- Orderly depolarization wave results a contraction wave in the myocardium

- Excitation–contraction coupling
  - Results contractile response
  - Begins just after the start of depolarization
  - Lasts about until about 50ms after repolarization

- Contraction of the chambers –systole
- Relaxation of the cambers- diastole

Cardiac Cycle

- Atrial systole stars just after the P wave
- Ventricular systole starts near the end of the R wave and ends just after the T wave
- Contraction produces
  - Sequential changes in pressures and flows in the heart chambers and vessels
- Blood pressures
  - Systolic pressure-Highest pressure during systole in aorta
  - Diastolic pressure-Lowest pressure during diastole in aorta

Cardiac Cycle

- Mechanical events of the cardiac cycle
- Following are the phases of the cardiac cycle

1. Late diastole
2. Atrial systole
3. Ventricular systole
4. Early diastole

Cardiac Cycle

1. Events in late diastole
   - Mitral and the tricuspid valves are opened
   - Aortic and the pulmonary vales are closed
   - Blood flows into the heart throughout diastole
   - Filling of the atria and the ventricles
   - The rate of filling declines as the ventricles become distended
   - The cusps of the mitral and tricuspid valves drift toward the closed position
   - The pressure in the ventricle remains low

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2. Atrial systole

- Contraction of the atria propels additional blood into the ventricles
- But 70% of the ventricular filling occurs passively during diastole
- During atria systole some blood regurgitates into the great veins

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3. Ventricular systole

- Has
  1. Isovolumetric (isovolumic, isometric) ventricular contraction
  2. Ventricular ejection

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3. Ventricular systole-Isovolumetric ventricular contraction

- Lasts about 0.05 second
- At the start of ventricular systole the mitral and tricuspid vales close and aortic pulmonary valves remain closed
- All the valves are closed and ventricles are closed chambers for a short period of time

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3. Ventricular systole-Isovolumetric ventricular contraction
   - Ventricles contracts very little
   - But ventricular pressure rises very rapidly as the myocardium presses on the blood
   - The pressure in the ventricles exceeds the pressure in the great arteries

- During this time the cusps of AV valve bulge into atria causing a small but sharp rise in atrial pressure

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3. Ventricular systole- Ventricular ejection

- When the pressure in the left ventricle exceeds aortic artery pressure the aortic valve opens
- When the pressure in the right ventricle exceeds pulmonary artery pressure the pulmonary valves open
- The phase of ventricular ejection begins
- Blood ejects into aorta and pulmonary artery
- The intraventricular pressure rises to a maximum and then declines before the end of ventricular systole
- Therefore the ejection is rapid at first and the slows down

Cardiac Cycle

3. Ventricular systole- Ventricular ejection

- Peak left ventricular pressure is about 120mmHg
- Peak right ventricular pressure is about 25mmHg
- Late in the systole the aortic pressure actually exceeds the ventricular pressure
- But momentum keeps the blood moving forward into the aorta
- The AV valves are pulled down by the contraction of the ventricles
- And the atrial pressure drops

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4. Early diastole

- Protodiastole-lasts for 0.04 seconds
  - When the ventricular muscle is fully contracted the falling ventricular pressure drop more rapidly
  - Ends when the momentum of the ejected blood is overcome
  - The aortic and pulmonary valves close

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4. Early diastole

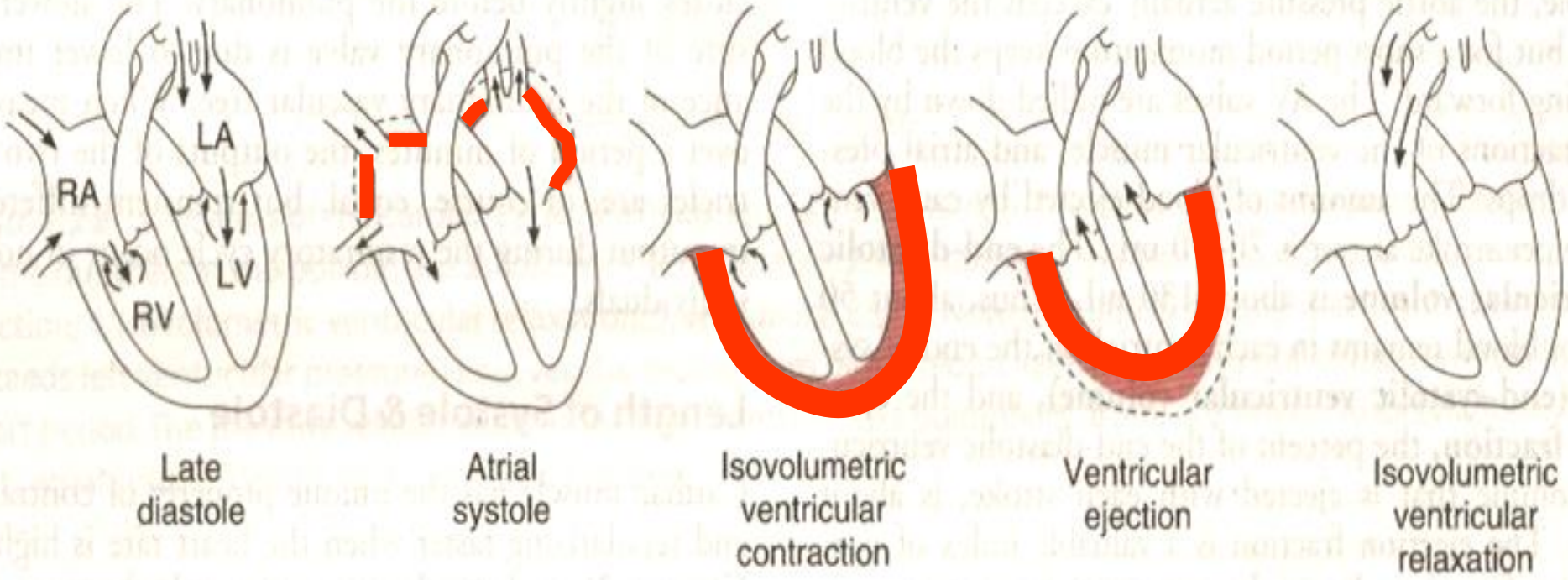
- The isovolumetric relaxation
  - The AV valves, aortic and pulmonary valves are closed
  - Pressure continue to drop rapidly
  - When the ventricular pressure falls below the atrial pressure the AV valves open
  - Resulting end of the isovolumetric relaxation
- When AV valves open ventricular filling starts

Cardiac Cycle

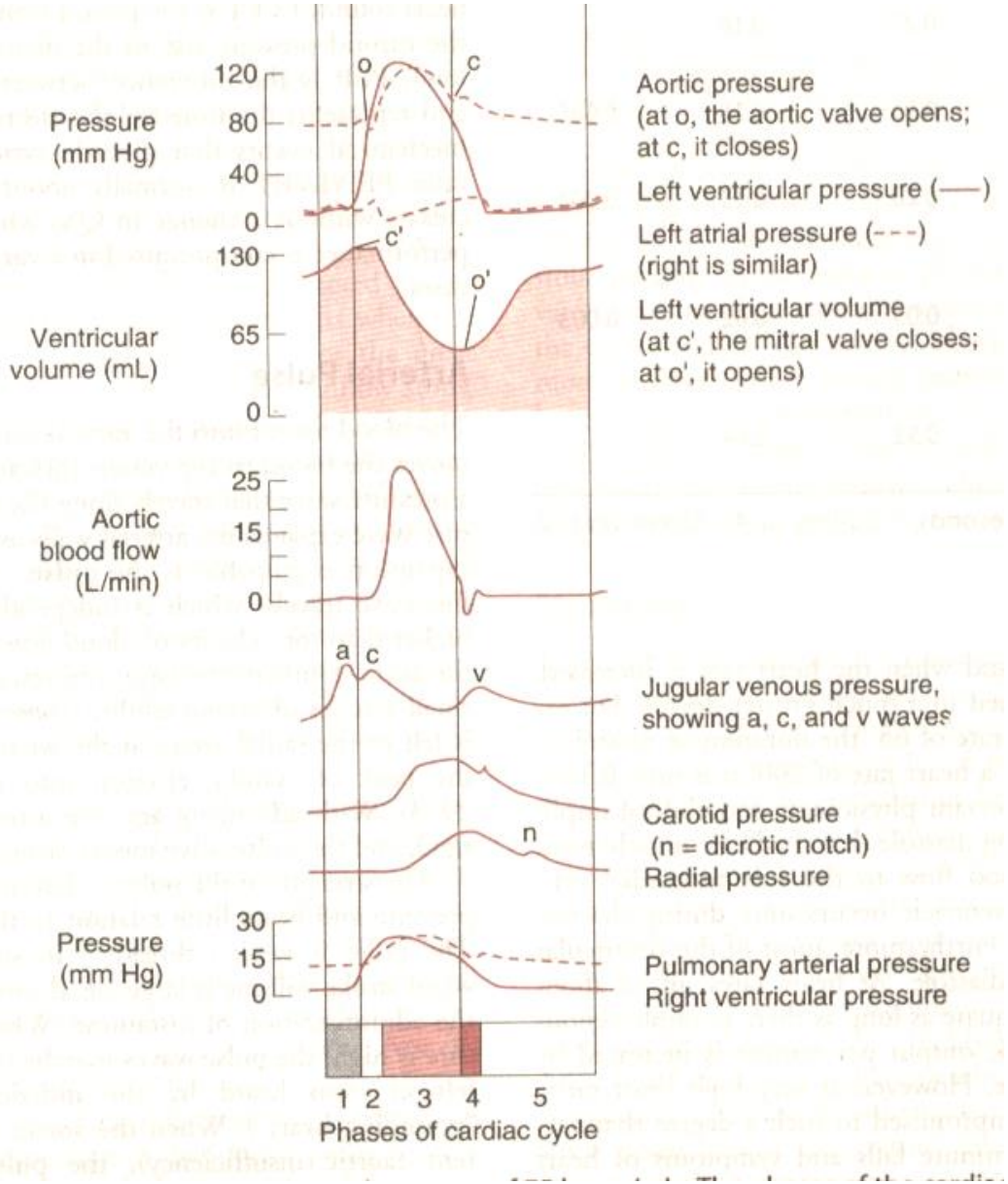
4. Early diastole

- Ventricular filling is rapid at first
- Slows down towards the late diastole

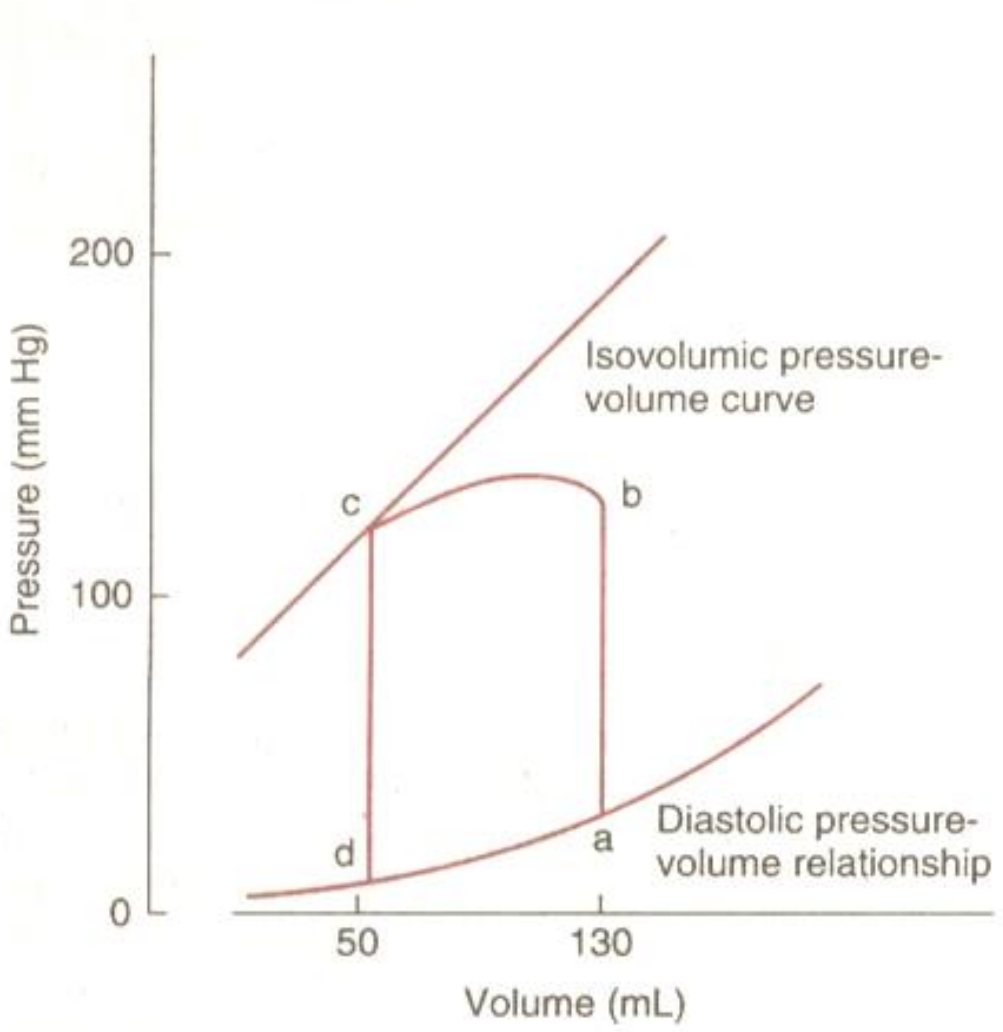
Cardiac Cycle



Cardiac Cycle



Cardiac Cycle



Cardiac Cycle

- Atrial pressure continues to rise after the ventricular systole until the AV valves open
- Timing of the events
  - The activities of the right and left side are asynchronous
  - Right atrial systole precedes the left atrial systole
  - Left ventricular systole precedes the right
  - Right ventricular ejection begins before the left ventricular ejection
- During inspiration the aortic valve closes slightly before pulmonary valve
- During expiration both valve close at the same time

Cardiac Cycle

- **Cardiac chamber volumes**
- **End diastolic volume**
  - The volume of the ventricles at the end of the diastole
  - About 130 ml
- **Stroke volume**
  - The volume of blood ejected from each ventricle during ventricular ejection (with each stroke)
  - About 70-90 ml at rest
- **End systolic volume**
  - Volume of blood remains in each ventricle at the end of systole
  - About 50 ml

Cardiac Cycle

- **Cardiac chamber volumes**
- Ejection fraction
  - Percentage of blood ejected with each stroke from the end diastolic volume
  - = stroke volume / end diastolic volume X 100%
  - Normally about 65%
  - Valuable index of ventricular function

Cardiac Cycle

- Length of systole and diastole
- With change of heart rate the length of systole and diastole varies
- With tachycardia the length of cardiac cycle decreases
  - Both the systolic and diastolic length decreases
  - The shortening is mainly due to reduction of the length of diastole

Arterial pulse

- The blood forced into the aorta during ventricular ejection
  - Moves the blood forward
  - Sets up a pressure wave that travels along the arteries
  - Expands the arterial wall
- This expansion is palpable as the pulse

Arterial pulse

- Character of the pulse
  - Slow rising pulse occurs in aortic stenosis
  - Collapsing pulse is seen with aortic regurgitation
  - Radio-femoral delay is seen with co-arctation of the aorta

- The rate, rhythm, character, volume, radio- femoral delay of the pulse –refer practical manual

Atrial pressure changes

- Atrial pressure
  - Rises during atrial systole
  - Starts to drop with atrial diastole
  - A transient rise is seen with isometric ventricular contraction when AV valve cups bulge into the atria
  - With ventricular ejection pressure drops rapidly due pulling of the AV valve and continues to drop due to atrial diastole
  - Atrial pressure rises again due to venous return in ventricular systole
  - When AV valve opens in ventricular diastole pressure drops again

Jugular venous pulse

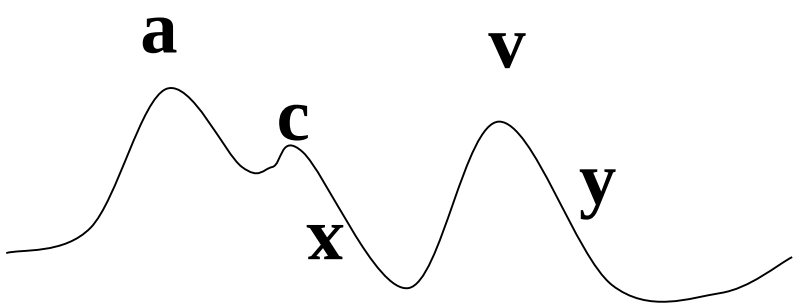
- The atrial pressure changes are transmitted to the great veins
- These pressure fluctuations can be seen in the internal jugular veins in the neck
- Produces three characteristic waves
  - Three positive waves ‘a,c and v’
  - Two descents ‘x and y’

Jugular venous pulse

- The ‘a’ wave due to
  - atrial systole
  - Regurgitation of blood into the great veins with atrial systole
  - Stoppage of venous flow in great veins
- The ‘c’ wave due to
  - Transmitted pressure due to bulging of the cusp of AV valves during isovolumetric ventricular contraction

Jugular venous pulse

- The ‘v’ wave due to
  - Rise of atrial pressure due to venous return in ventricular systole
- The ‘x’ descent due to atrial diastole
- The ‘y’ descent due to opening of tricuspid valve in ventricular diastole



Jugular venous pulse

- Abnormal jugular venous pulse
  - Large ‘a’ wave is seen in complete heart block when atria contracts with closed AV valves
  - Giant ‘c’ wave is seen in tricuspid regurgitation
  - Q – Can you see ‘a’ wave in atrial fibrillation?