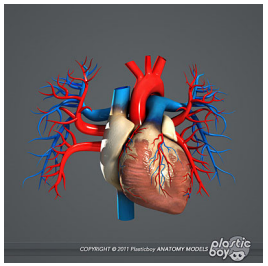
MECHANICAL EVENTS IN THE CARDIAC CYCLE



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Objectives of this lecture

Understand the different phases of the cardiac cycle and how the following parameters vary in each of the phases

- **Left ventricular pressure**
- **Aortic pressure**
- **Left atrial pressure**
- **Ventricular volume**
- **Opening and closing of valves**
- **Heart sounds**
- **The ECG**

- **cardiac events from beginning of one heartbeat to the beginning of the next = cardiac cycle.**
- **delay of >1/10 sec between passage of impulse from atria to ventricles - allows atria to contract ahead of ventricles – atria act as primer pumps for the ventricles & ventricles then provide major source of power for moving blood through the vascular system.**
- **electrical event occurs just prior to its corresponding mechanical event.**

- **cardiac cycle consists of alternate periods of relaxation & filling = diastole and contraction and emptying = systole**
- **atria & ventricles go through separate cycles of systole & diastole**

We are now going to look at

- **pressure changes in the left ventricle**
- **pressure changes in the aorta**
- **pressure changes in the left atrium**
- **ventricular volume**
- **points of opening and closing of valves**
- **generation of heart sounds**
- **the ECG**

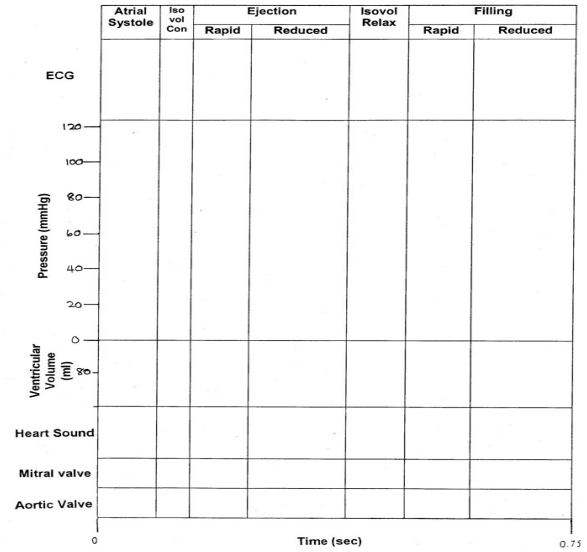
PHASES OF THE CARDIAC CYCLE

1. atrial systole
2. isovolumetric ventricular contraction
3. rapid ejection phase
4. reduced ejection phase

} ventricular systole

5. isovolumetric ventricular relaxation
6. filling - rapid & reduced

} ventricular diastole



1. ATRIAL SYSTOLE

- SA node initiates electrical activity – spreads throughout atria (P wave in ECG)
- atrial contraction follows - atrial pressure ↑ (a wave)
- mitral/bicuspid valve open, aortic valve closed
- as atria contract, ventricle is filling as blood is pushed through mitral valve - small ↑ in ventricular volume to reach end-diastolic volume
- ↑ in ventricular volume → slight ↑ ventricular pressure
- pressure in aorta starts to ↓ - aortic valve is closed ∴ no more blood enters aorta and that already there is moving into systemic circulation

2. VENTRICULAR EXCITATION & ISOVOLUMETRIC VENTRICULAR CONTRACTION

- electrical activity spreads through ventricles (QRS complex)
- electrical depolarisation → ventricular contraction
- ventricular pressure rises abruptly → mitral valve closure (first heart sound) (valve closes when ventricular pressure exceed atrial pressure)
- ventricle now a closed chamber which is contracting causing an ↑ in ventricular pressure
- no change in intraventricular volume (isovolumetric) - all valves are closed
- during isovolumetric ventricular contraction, AV valves bulge into atria - small sharp ↑ in atrial pressure (c wave)
- aortic pressure continues to fall

3. RAPID EJECTION PHASE

- when LV pressure ↑ slightly above aortic pressure, the ventricular pressure pushes the aortic valve open & ventricular ejection begins
- blood pours out of the ventricles so ventricular volume ↓ - ±70% of the emptying occurs during the first 1/3 of the period of ejection = rapid ejection phase.
- ventricular pressure approaches its maximum
  - » Peak LV pressure is about 120 mm Hg
  - » (Peak RV pressure is about 25 mm Hg)
- aortic pressure ↑ as blood ejects into aorta
- atrial pressure ↓ as AV valves no longer bulge back into the atria

4. REDUCED EJECTION PHASE

- remaining 30% of ventricular emptying occurs so ventricular volume continues to ↓
- contractile forces of the heart are ↓ and so is the intraventricular pressure.
- blood flow from heart begins to slow down so aortic pressure starts to fall
- repolarisation of the myocardium occurs (T wave)
- end of this phase represents the end of ventricular systole
- some blood is flowing back into the atria so atrial pressure starts to ↑ a little

5. ISOVOLUMETRIC RELAXATION

- ventricular relaxation begins and intraventricular pressure ↓ rapidly
- ↑ pressures in large arteries push blood back towards the ventricles - snaps aortic & pulmonary valves closed = 2nd heart sound
- dicrotic notch = small oscillation on falling phase of aortic pulse wave due to vibrations set up when the aortic valve snaps shut
- both valves closed - no blood is leaving or entering ventricles. Ventricular vol at its lowest = end-systolic volume
- ventricular pressure ↓ but no change in ventricular volume
- blood flows into atria - atrial pressure ↑ (v wave)

6. RAPID & REDUCED FILLING PHASES

- ventricular pressure less than atrial, so AV valves open
- aortic & pulmonary valves are closed
- blood fills into atria & then directly into ventricles so atrial pressure falls and
- ventricular volume increases but ventricular pressure remains low
- in reduced filling phase, pressure remains low and ventricular filling is slow so ventricular volume ↑ only a little
- aortic pressure ↓ as blood is draining away and no further blood is entering the aorta
- towards the end of this phase atrial depolarisation starts and the cycle repeats itself