Practical 6 - CV

The heart as a pump: Phlebogram - Jugulogram. Sphygmogram – Carotidogram. Apexcardiogram. Polygram.

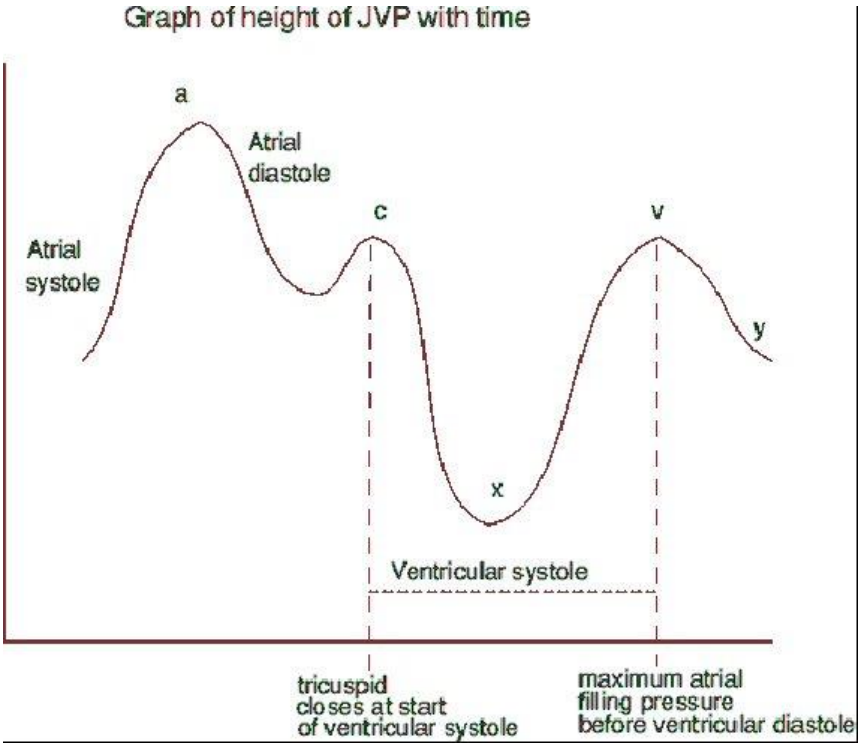
Events in the cardiac cycle:

- Electric events –ECG
- Acoustic events – phonocardiogram
- Mechanical events – mechanograms

Exploring the mechanical activity of the heart:

1. venous pulse - jugulogram
2. arterial pulse – carotidogram, sphigmogram
3. apex impulse - apexocardiogram
4. correlation between the cardiac cycle (ECG), phonocardiogram and mechanograms - polygram

1. **<u>The venous pulse wave - jugulogram</u>**



2. **<u>The arterial pulse wave</u>**

   Systolic pressure

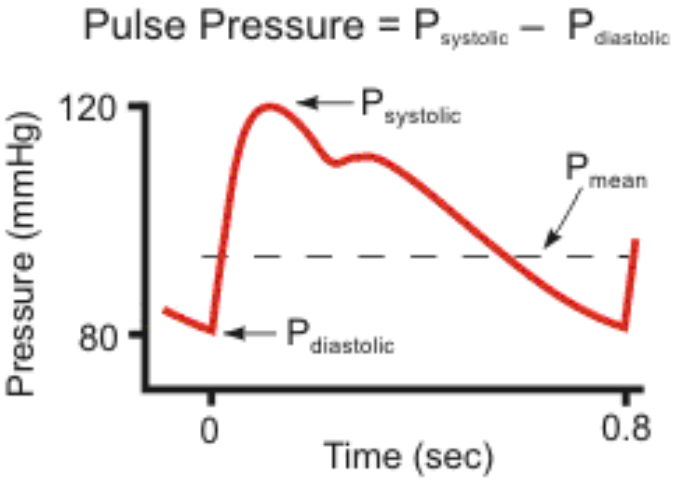
   Diastolic pressure

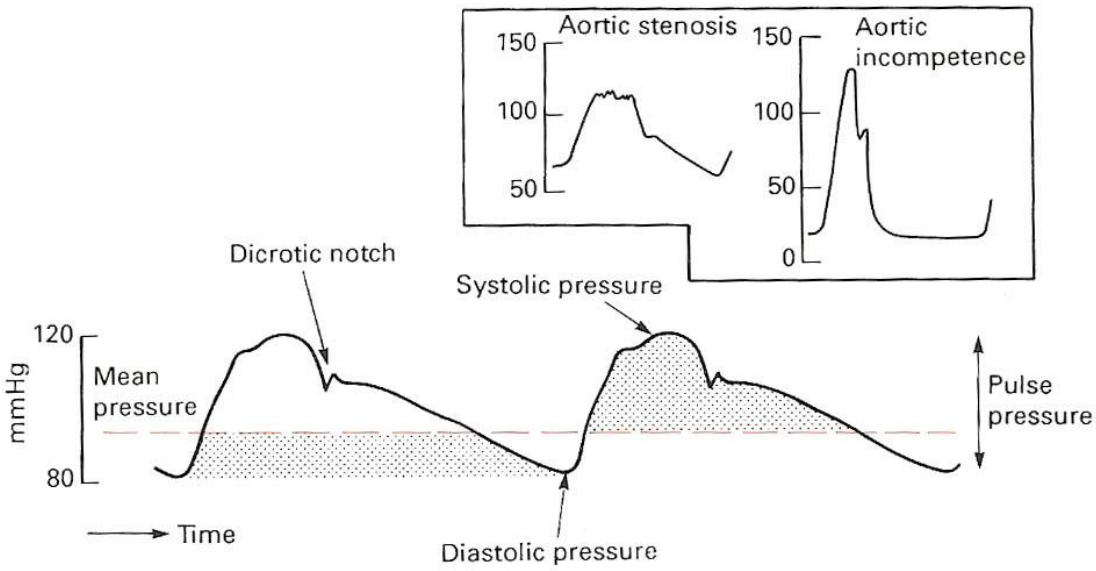
Pulse pressure

Pulse wave - recording of the pressure changes in an artery during one cycle of the heart

- Rapid ejection phase
- Dicrotic notch (incisura)
- Diastolic runoff

- direct relation with the stroke volume, and inverse related to the compliance/elasticity of the arterial vessels



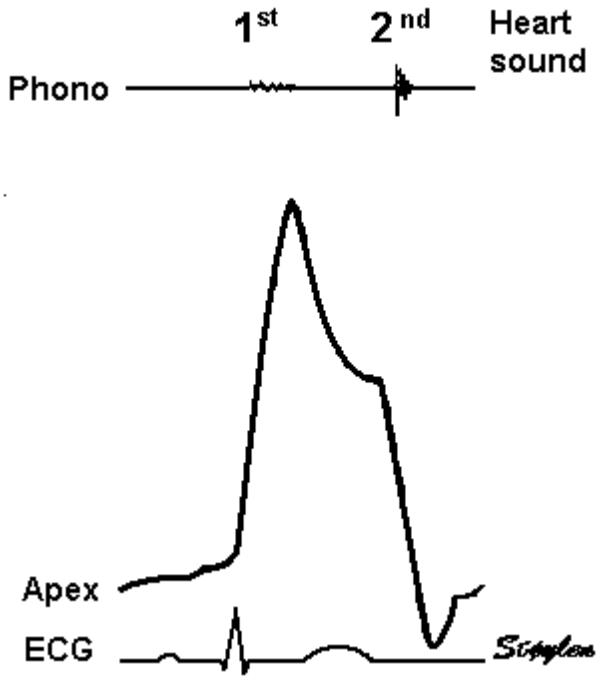


Pressure wave in human subclavian artery over two cycles recorded by an electronic pressure transducer. The mean pressure, averaged over time, is the pressure at which the area above the mean (grey area, $\int P \,.\, dt$) equals the area below the mean. Inset shows abnormal waveform in aortic valve stenosis (slow rise, prolonged plateau) and aortic incompetence (excessive pulse pressure, low diastolic pressure) (After Mills, C. J., Gale, I. T., Gault, J. H. *et al.* (1970) *Cardiovascular Research*, **4**, 405, omitting variable minor waves on the descending limb caused by reflections)

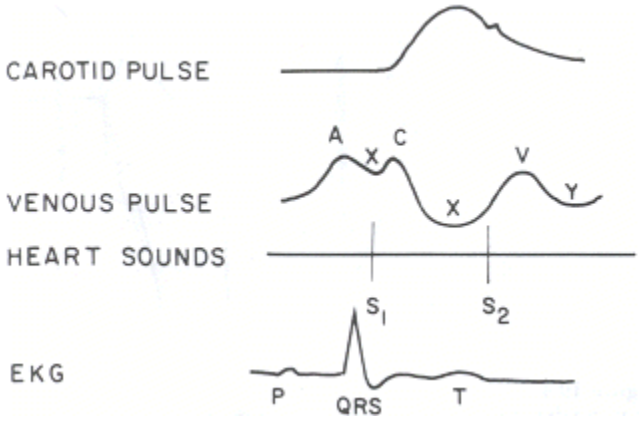
The velocity of the pulse wave as it travels down the arteries:
3-5 m /sec over large arteries
14-15 m/sec over the small, less compliant vessels
Velocity of the pulse wave increases with age.

Recording the peripheral pulse
Recording the pulse wave over an artery from the tip of the finger – peripheral pulse, using a photoelectric pulse transducer, which measures changes in blood volume (plethysmography). A light source in the transducer illuminates the finger tip, and a photoconductor detects changes in light intensity within the finger caused by pulsatile variations in blood volume.

3. <u>The apex impulse</u>

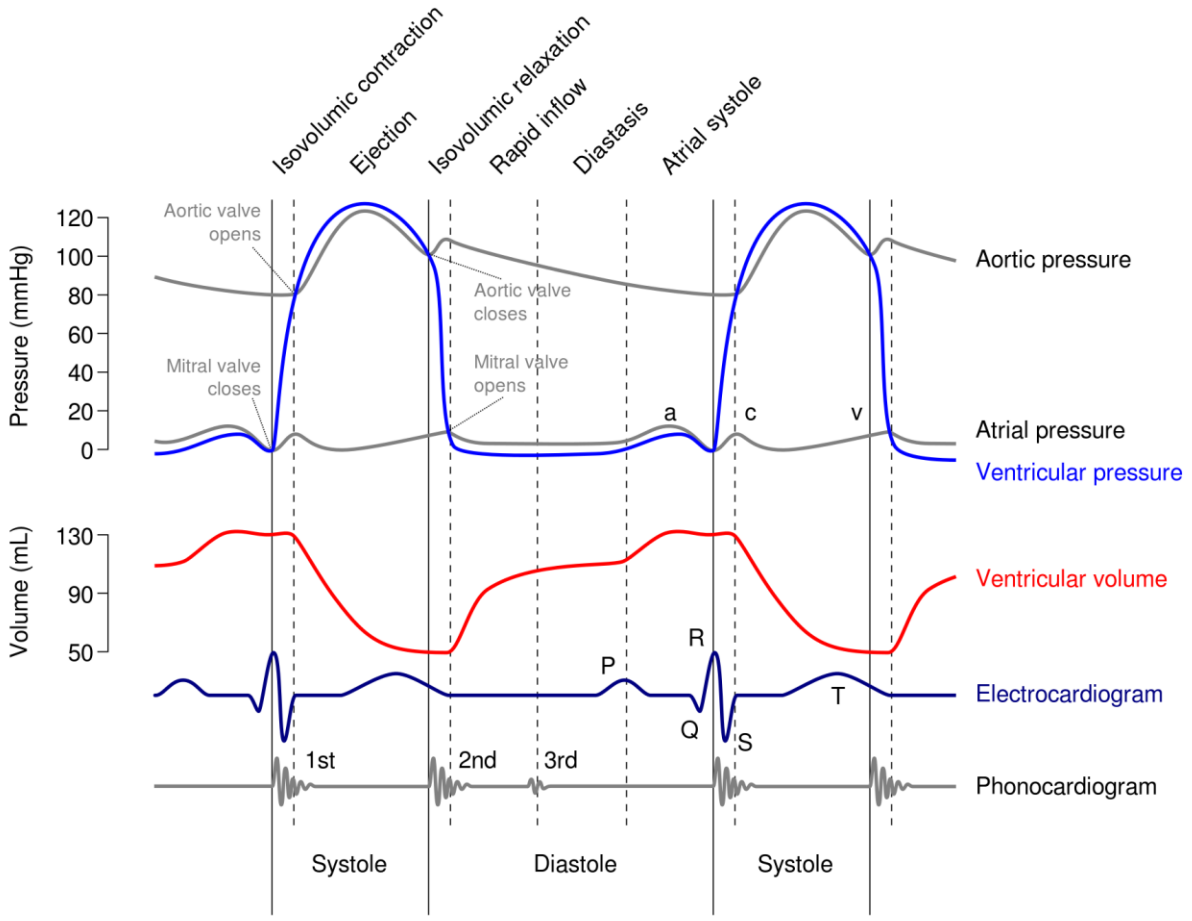


<u>The cardiac cycle and mechanograms - Polygram</u>



Polygram (Wiggers diagram)

1. Simultaneous recording of the carotid pulse, apexcardiogram, phonocardiogram, jugular pulse and electrocardiogram.
2. Useful for making connections between the electrical and mechanical events that happen during the cardiac cycle. Used for estimating periods in the cardiac cycle -the ejection period, pre-ejection period etc.



Systolic time intervals are calculated using the carotid pulse, phonocardiogram and the electrocardiogram. Duration of the left ventricular systole is calculated –Q-S2 interval.

3. For a better overview of events we will discuss each phase of the cardiac cycle with its typical recording features.

Interval	Measurement	Physiological event
Q-S2	Beginning of QRS to beginning of S2	Whole electromechanical systole
Q-S1	Beginning of QRS to beginning of S1	Excitation-contraction coupling
Isovolumic contraction	S1 to onset of aortic rise in pressure	
LV ejection time	From E point (beginning of ejection with opening of the aortic valves) on the carotidogram to dicrotic notch	Total ejection
Pre-ejection period	Q-S2 minus left ventricular ejection time	Isovolumic contraction plus Q-S1 interval

- **Atrial systole** –atria contracting**,** ventricles in diastole, atrioventricular valves open, semilunar valves closed.

1. **Carotid pulse:** positive a wave caused by the left atrial systole, transmitted through the venous pulse wave to the carotid.
2. **Apexcardiogram** : small positive *a wave* that begins after the middle of the P wave on ECG.
3. **Jugular pulse:** positive *a wave* caused by the right atrial systole
4. **Phonocardiogram:** S4 caused by the volume of blood set in motion by the atrial contraction that hits the ventricular wall.
5. **ECG:** P wave caused by depolarization of the atria (summation wave of the right and left depolarization)

- **Isovolumetric contraction-** atria in diastole, ventricles contracting, atrioventricular valves closed, semilunar valves closed.

1. **Carotid pulse:** no deflection
2. **Apexcardiogram: c point** marks the beginning of the isovolumetric contraction. **E point** represents the end of the isovolumetric contraction, opening of the aortic valves and the beginning of the ejection period.
3. **Jugular pulse:** part of positive *c wave* caused by the bulging of the tricuspid into the right atrium
4. **Phonocardiogram** : first heart sound caused mainly by closing of the AV valves
5. **ECG:** beginning of the mechanical systole does not coincide with the beginning of the electrical systole. The latter starts with the beginning of the QRS complex while the former begins with the closing of the AV valves; this happens shortly after the beginning of the QRS complex, usually when the R wave reaches its peak on the ECG.

- **Rapid ejection** - atria in diastole, ventricles contracting, atrioventricular valves closed, semilunar valves open.

1. **Carotid pulse :** E point (opening of the aortic valves) followed by the anacrotic limb with the P point (percussion wave) where the peak pressure is reached.
2. **Apexcardiogram**: initial part of EH descending slope
3. **Jugular pulse**: - the rest of the c wave, produced by the pulsation of the nearby carotid artery during initial ejection, followed by the **x descent**, due to atrial relaxation and descent of the floor of the right atrium during right ventricular systole.
4. **Phonocardiogram:** pathological early systolic clicks (sound) produced by the opening of stenotic but flexible aortic/pulmonary valves.
5. **ECG**: - ST segment - all the myocardium is depolarized, no potential difference.

- **Slow ejection**- atria in diastole, ventricles contracting less forcefully, atrioventricular valves closed, semilunar valves open.

1. **Carotid pulse**: - a tidal wave may appear because of reflection from the upper part of the body during the initial decrease in pressure because of slower ejection.
2. **Apexcardiogram** : - second part of EH descending slope

3. **Jugular pulse**: - the x descent continues to the point where the semilunar valves close
4. **Phonocardiogram**: - pathological mid systolic clicks caused by mitral valve prolapse
5. **ECG**: - *T wave* – ongoing repolarization of the myocardium with gradual decrease in the force of contraction.

- **Isovolumetric relaxation**- general diastole -atria in diastole, ventricles in diastole, atrioventricular valves closed, semilunar valves closed.

1. **Carotid pulse:** dicrotic notch when the aortic valves close, followed by the *dicrotic wave* caused by the tendency of blood to flow back into the heart, hitting against the closed aortic valves and re-distending the aortic walls.
2. **Apexcardiogram**: *H point* marks the beginning of the isovolumetric relaxation, followed by the *HO slope*.
3. **Jugular pulse :** ascending *v wave*, due to filling of the atria and increasing atrial pressure, up to the *v point* where the tricuspid valve opens
4. **Phonocardiogram:** - second heart sound (S2) caused by closing of the aortic valves followed by the pulmonary valves (reason for physiological sound splitting during inspiration)
5. **ECG**: -isoelectric segment- *TP segment*, all the myocardium is repolarized.

- **Rapid filling** - atria in diastole, ventricles in diastole, atrioventricular valves open, semilunar valves closed.

1. **Carotid pulse**: - *dicrotic limb*
2. **Apexcardiogram:** *Point O* (opening) marks the opening of the mitral valve and *point F* (filling) represents the rapid filling phase.
3. **Jugular pulse**: -descending *y slope* down to *y point*
4. **Phonocardiogram**: -pathological *opening snap* caused by mitral/tricuspid stenosis with flexible valves.
5. **ECG** : *TP segment*

- **Decreased filling (diastasis)-** atria in diastole, ventricles in diastole, atrioventricular valves open, semilunar valves closed.

1. **Carotid pulse**: **-** *dicrotic limb*
2. **Apexcardiogram**: *SF wave* represents the slow filling phase
3. **Jugular pulse**: ascending slope between the *y point* and the *a wave*, called *H slope*; the slope is ascending because more blood comes from the veins than it empties into the ventricle, because of reduced pressure gradient.
4. **Phonocardiogram**: - no physiological sounds, mitral stenosis murmur can be heard after the opening snap.
5. **ECG**: - *TP segment*