DEPARTMENT OF ELECTRONIC AND TELECOMMUNICATION ENGINEERING UNIVERSITY OF MORATUWA

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BM 2101 - Analysis of Physiological Systems

ANALYSIS OF CARDIAC PHYSIOLOGY

This is submitted as a partial fulfillment for the module
BM 2101 - Analysis of Physiological Systems

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December 21, 2019

1. NORMAL SINUS RHYTHM

a. Aortic valve

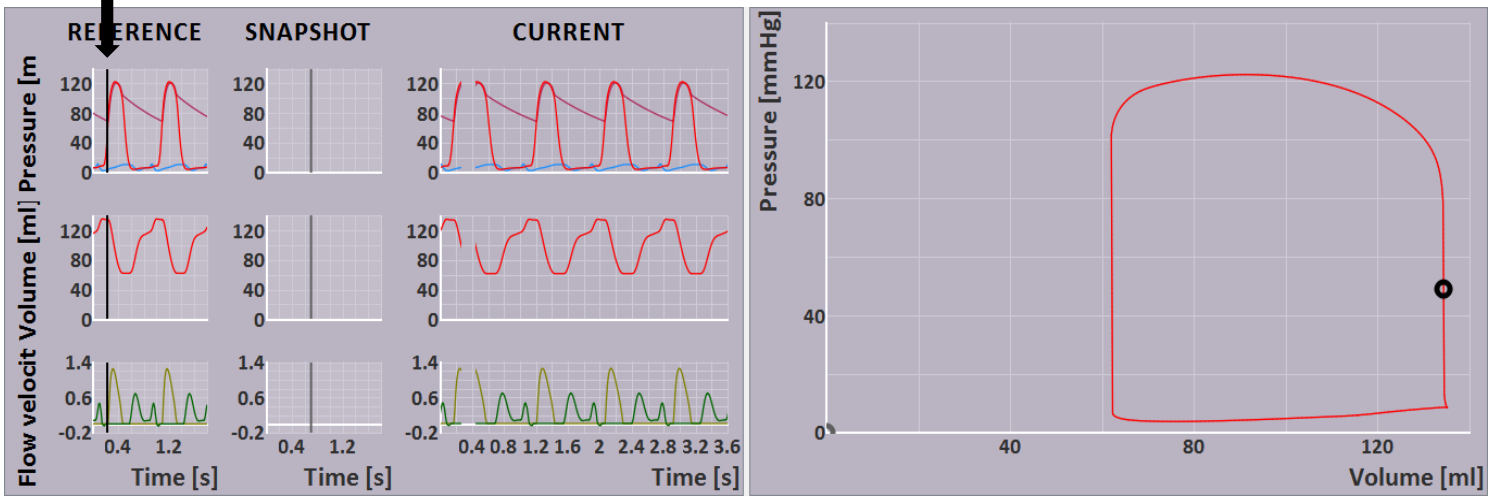

Figure 1-AORTIC VALVE OPENS

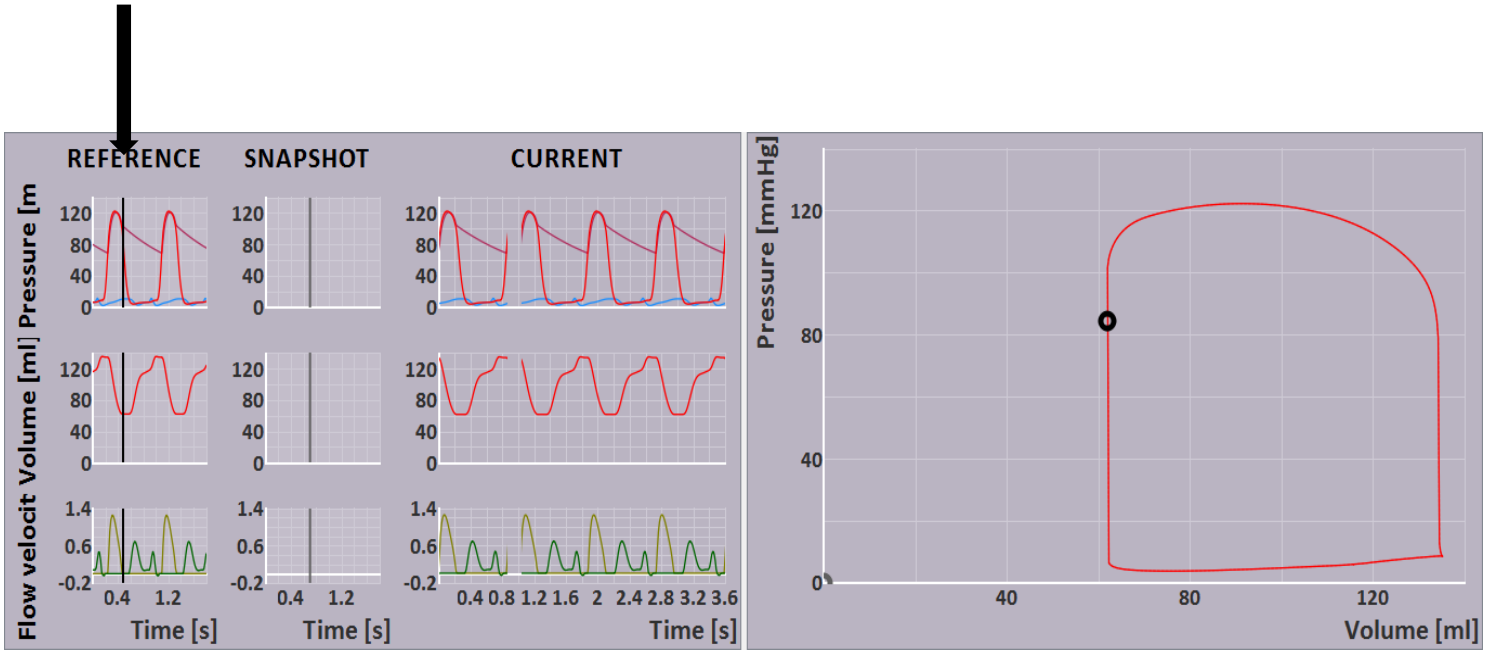

Figure 2 -AORTIC VALVE CLOSES

B. Mitral valve

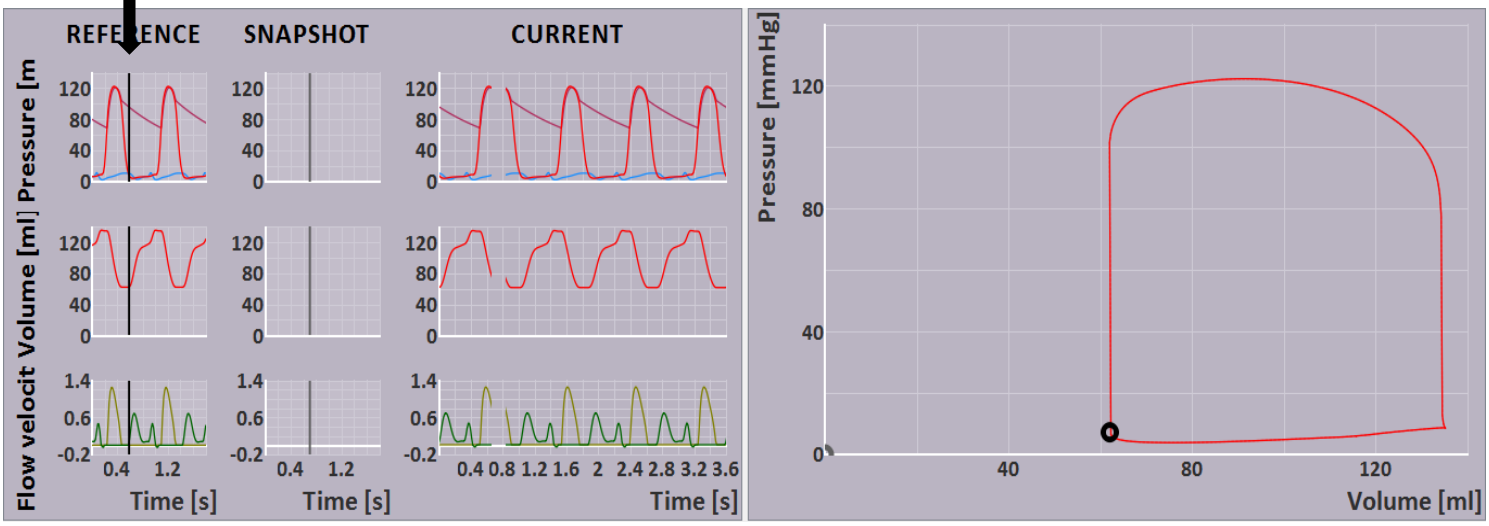

Figure 3-MITRAL VALVE OPENS

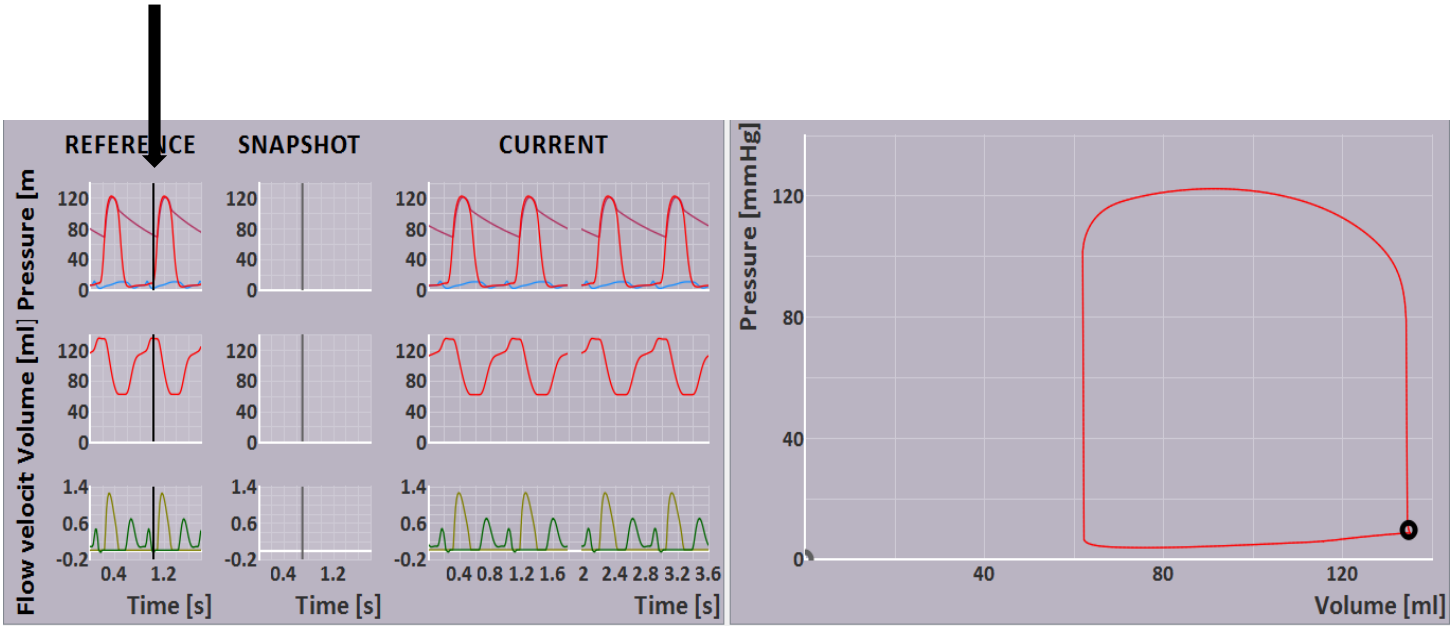

Figure 4-MITRAL VALVE CLOSES

C. Pressure-volume relation

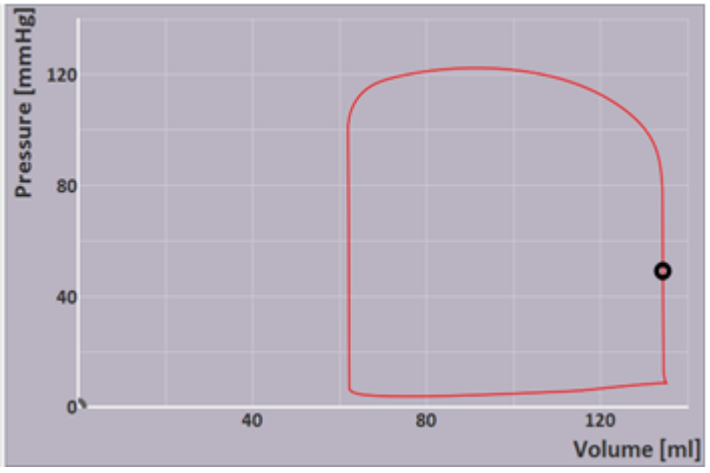

Figure 5-AORTIC VALVE OPENS

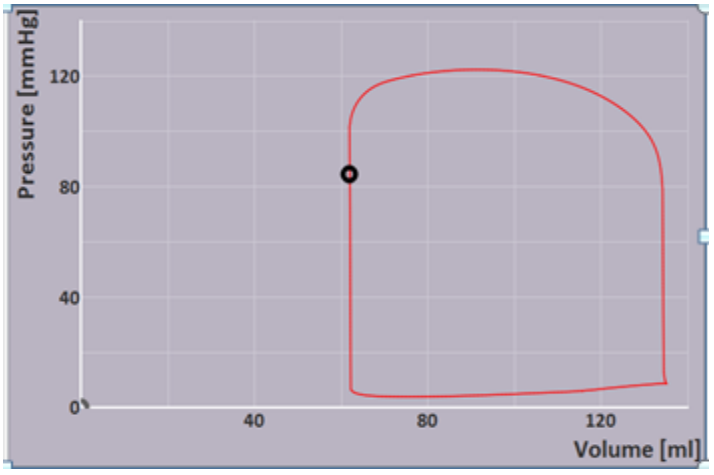

Figure 6-AORTIC VALVE CLOSES

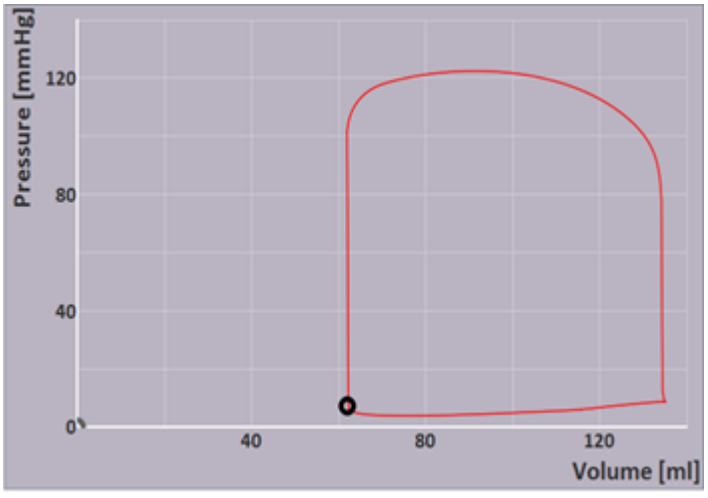

Figure 7-MITRAL VALVE OPENS

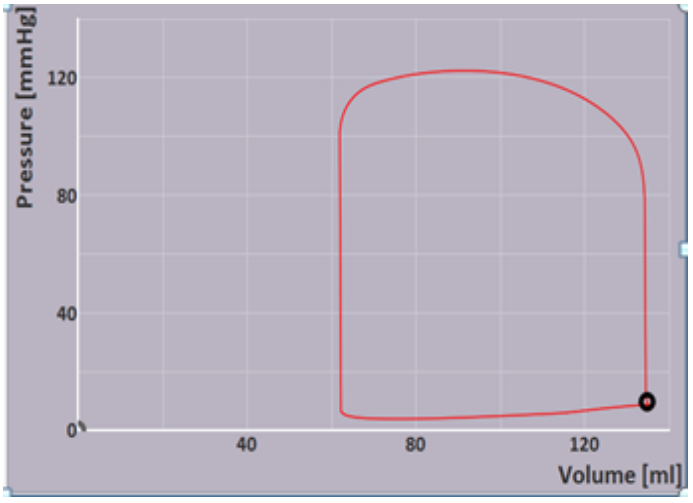

Figure 8-MITRAL VALVE CLOSES

D.

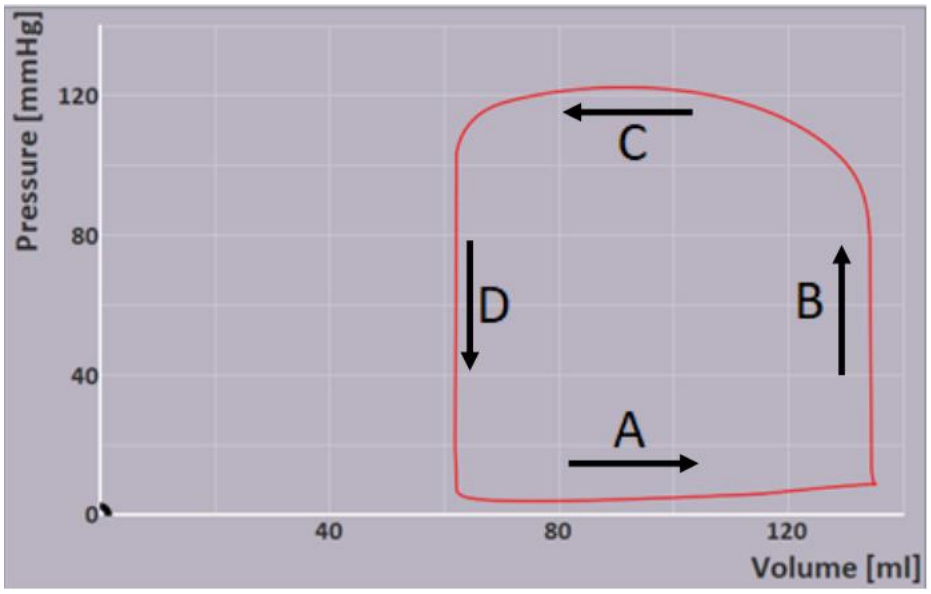

Figure 9-Left Ventricle pressure-volume graph

A. Filling
B. Isovolumetric Contraction
C. Ejection
D. Isovolumetric Relaxation

E.

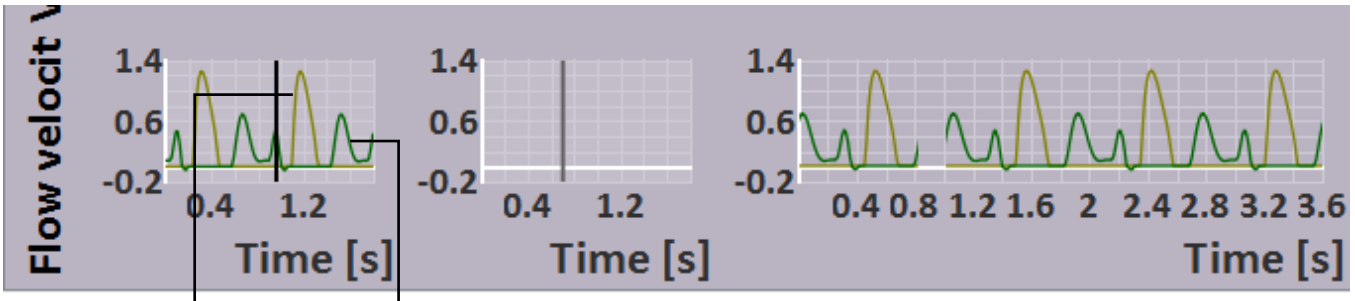

Figure 10-flow velocity graph

Aortic valve Mitral valve

- The only hump in flow velocity pattern of aortic valve is due to the opening and closing of Aortic valve.
- There is a maximum can be observed in the pattern and that is when left ventricle pressure reaches its maximum.
- There are two humps if flow velocity of mitral valve.
- The first one is due to passive filling
- In this phase there is rapid blood flow from left atrium to left ventricle and with time it reduces
- The second one is due to active filling.
- In this phase left atrium again contacts so the blood flow increase and then slows with time#

F.

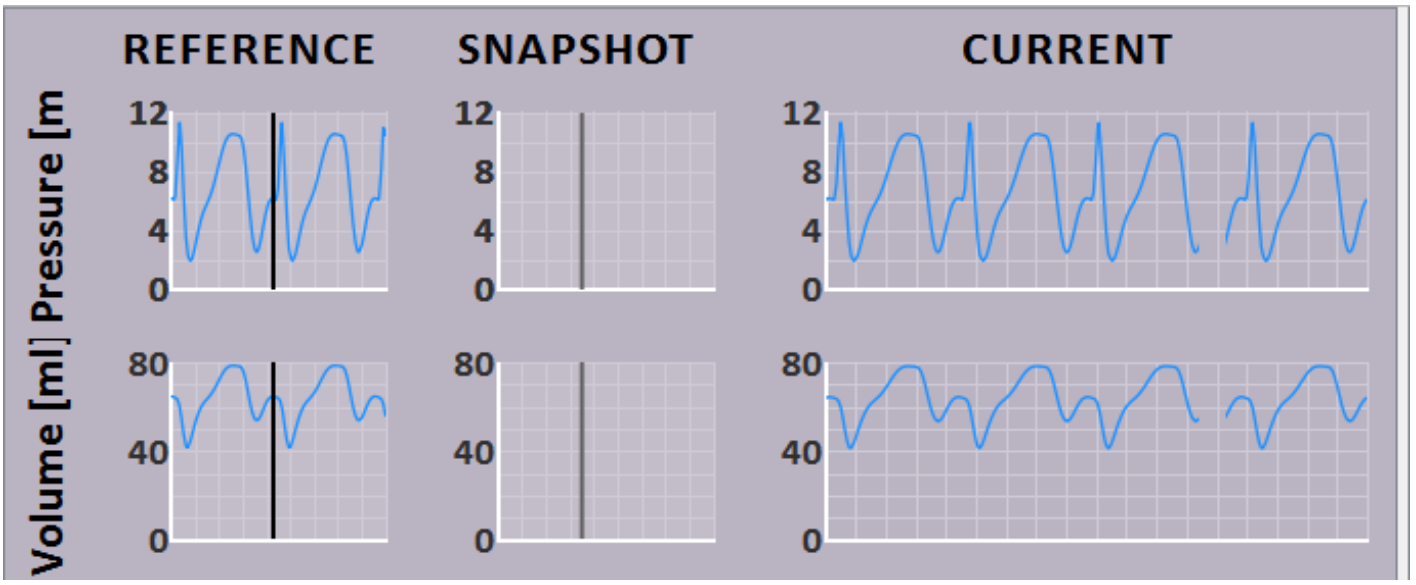

Figure 11-Left Atrial pressure and volume

- Slow Increase- **Atrial diastole** where blood fills left atrium slowly. So we can observe a rather slow increase in pressure and volume.
- Steep increase – Atrial systole where left contracts and pumps blood to left ventricle. So we can observe a steep increase in pressure and a steep decrease in volume graph.
- P Wave- steep increase in left atrium pressure.

G.

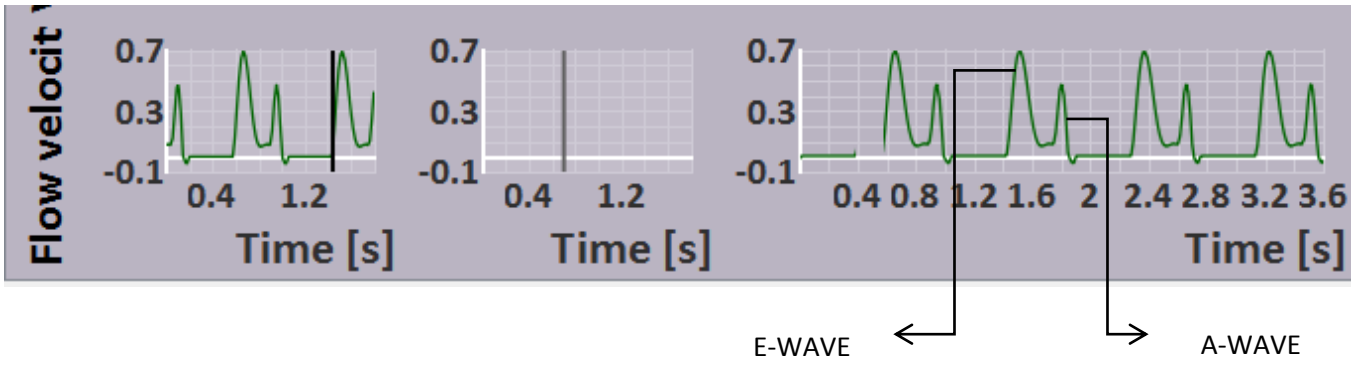

Figure 11-flow velocity graph of mitral valve

H. E/A Ratio

Amplitude of E-Wave	= 0.689 m/s
Amplitude of A-Wave	= 0.461m/s
E/A ratio of the stimulated mitral flow velocity	= 1.494

I.

Volume filled due to passive filling = (121-62)ml=59 ml
Volume filled due to active filling = 17ml (approximately)

J. Area(diameter) of the valve

2. AORTIC VALVE STENOSIS

A.

Pre-load:- For cardiac contraction, the ***preload*** is usually considered to be the end-diastolic pressure when the ventricle has become filled.

After-load:- The ***afterload*** of the ventricle is the pressure in the artery leading from the ventricle. Sometimes the afterload is loosely considered to be the resistance in the circulation rather than the pressure

B.

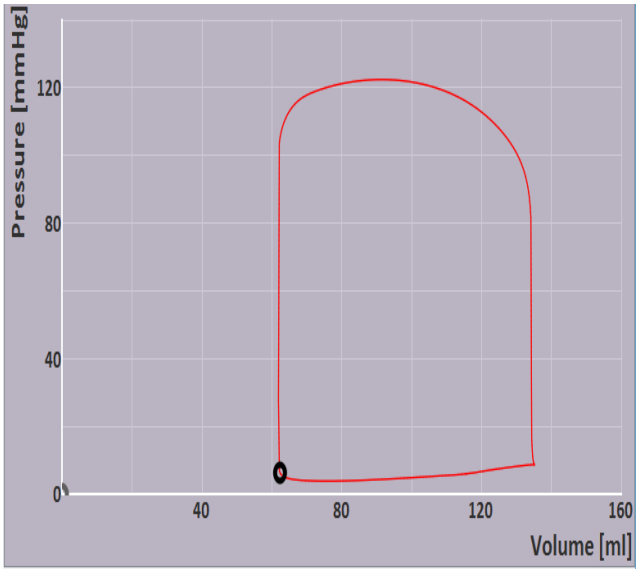

Figure 12-Aortic stenosis=0%

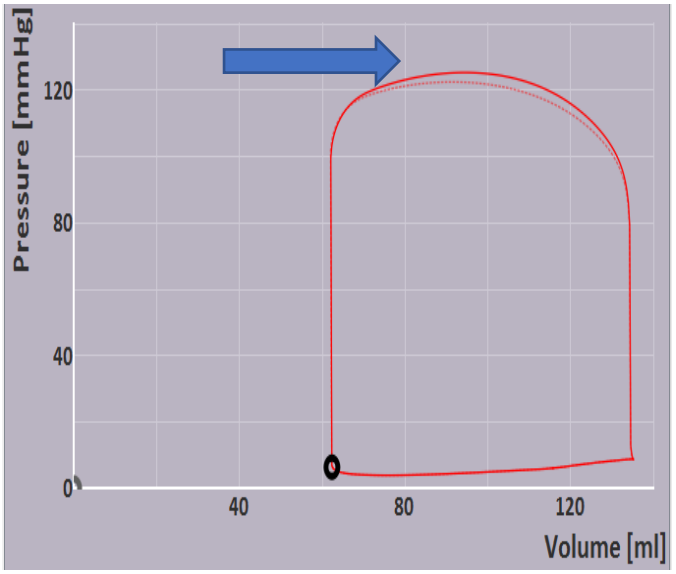

Figure 13- Aortic stenosis – 25% [left ventricular pressure increases during ejection]

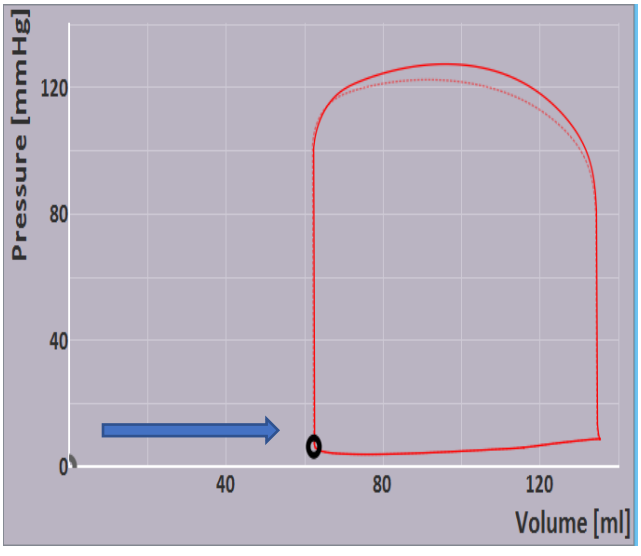

Figure 14- Aortic stenosis -35% [graph starts to shift right]

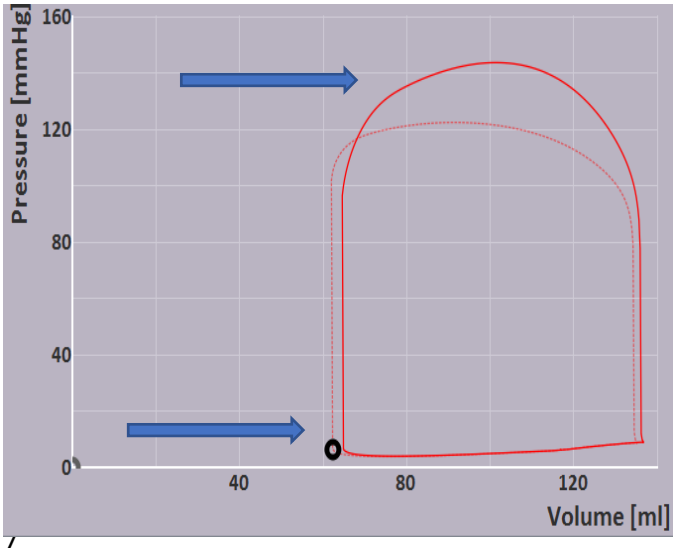

Figure 15- Aortic sienosis-65%[increase in right shift and left ventricular pressure]

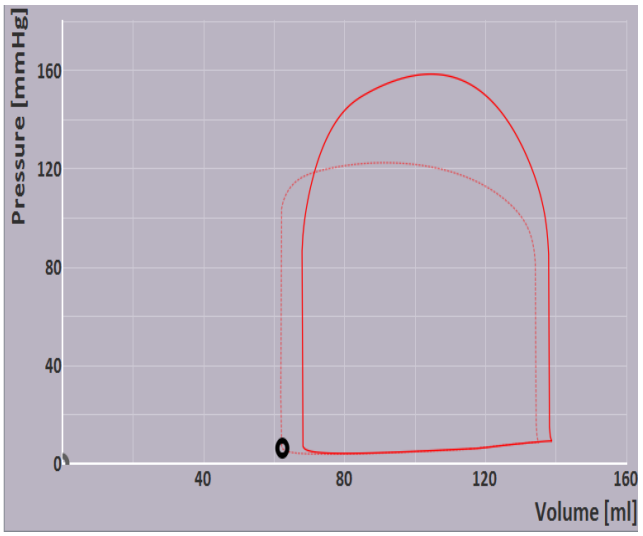

Figure 16- Aortic stenosis-75%

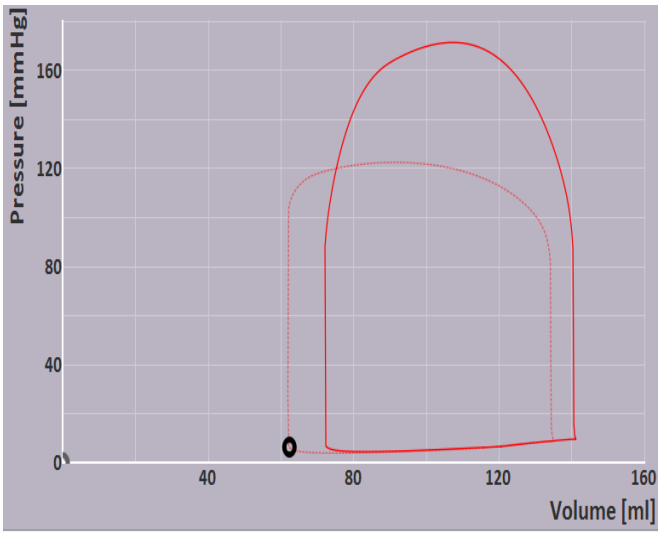

Figure 17-Aortic stenosis-80%

C.

In aortic stenosis (dark red loop in figure below), left ventricular emptying is impaired because of high outflow resistance caused by a reduction in the valve orifice area when it opens. This high outflow resistance causes a large pressure gradient to occur across the aortic valve during ejection, such that the peak systolic pressure within the ventricle is greatly increased. This leads to an increase in ventricular wall stress (afterload), a decrease in stroke volume, and an increase in end-systolic volume. Stroke volume (width of PV loop) decreases because the velocity of fibre shortening is decreased by the increased afterload. Because end-systolic volume is elevated, the excess residual volume added to the incoming venous return causes the end-diastolic volume to increase. This increases preload and activates the Frank-Starling mechanism to increase the force of contraction to help the ventricle overcome, in part, the increased outflow resistance.

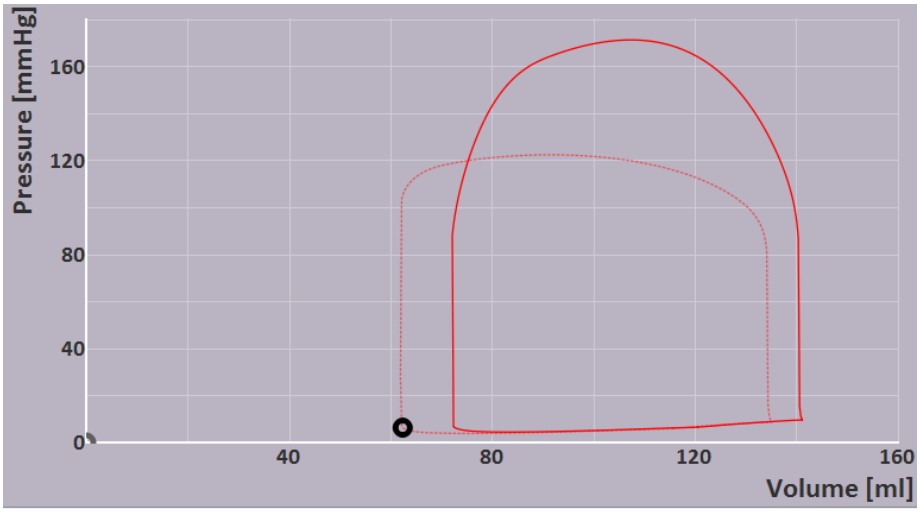

Figure 17

D.

Aortic pressure when maximum left ventricular pressure is 173 mmHg = **106 mmHg**

Pressure drop across the stenotic aortic valve = (173-106) = **67 mmHg**

E.

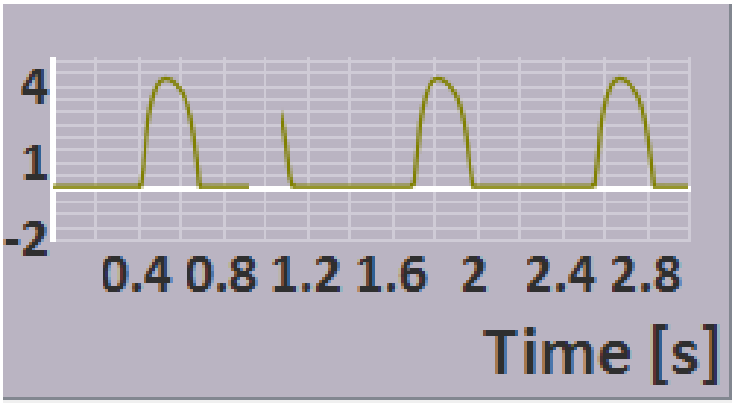

Figure 18- flow velocity graph of aortic valve

Maximum flow velocity in aortic valve (v) = 4.2 m/s

Then maximum pressure drops across aortic valve Δp = $4 \times (4.2)_2 = 70.56$ mmHg

- **Δp is increased**

F.

Duration of ejection = (0.47-0.24) s = 0.29 s

G.

Increase in external pump work generated by the left ventricle due to 80% AS = (26-23)/23% =13.043%

(Calculation is based on the no of squares enclosed by the cycle)

H.

Thickening of muscle walls and impaired filling will act as main cause to generate chronically increased pump work. These causes will lead to thickening of myocardial tissues. Myocardial tissues have the ability to overcome afterload due to their less compliance nature. The wall thickness greatly increases as new sarcomeres are added in-parallel to existing sarcomeres. So, the cardiac wall will have less wall stress. As a result, this adaptation reduces the afterload.