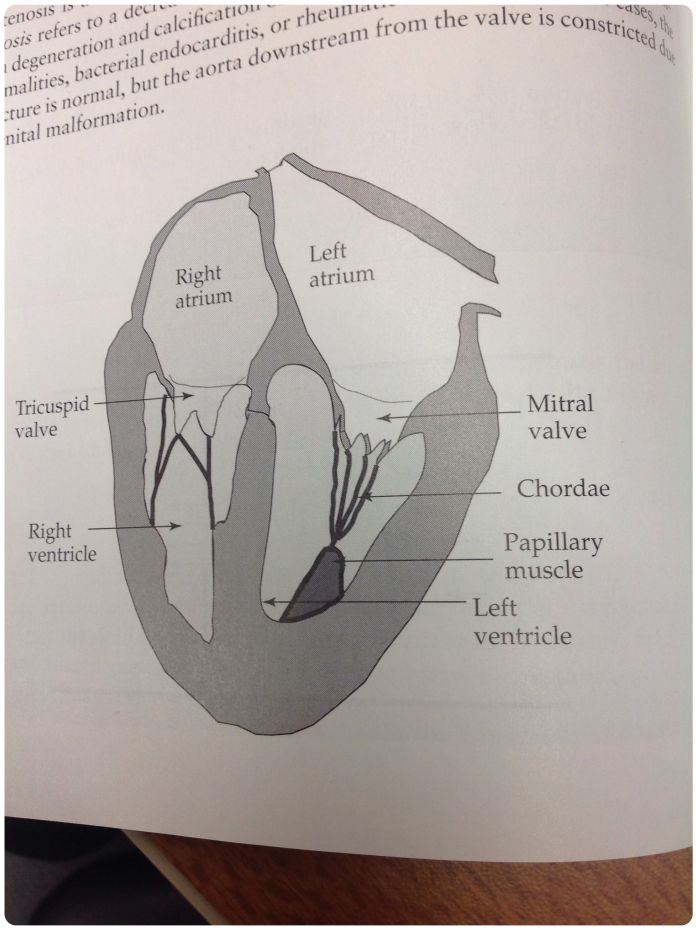
Flow through stenotic heart

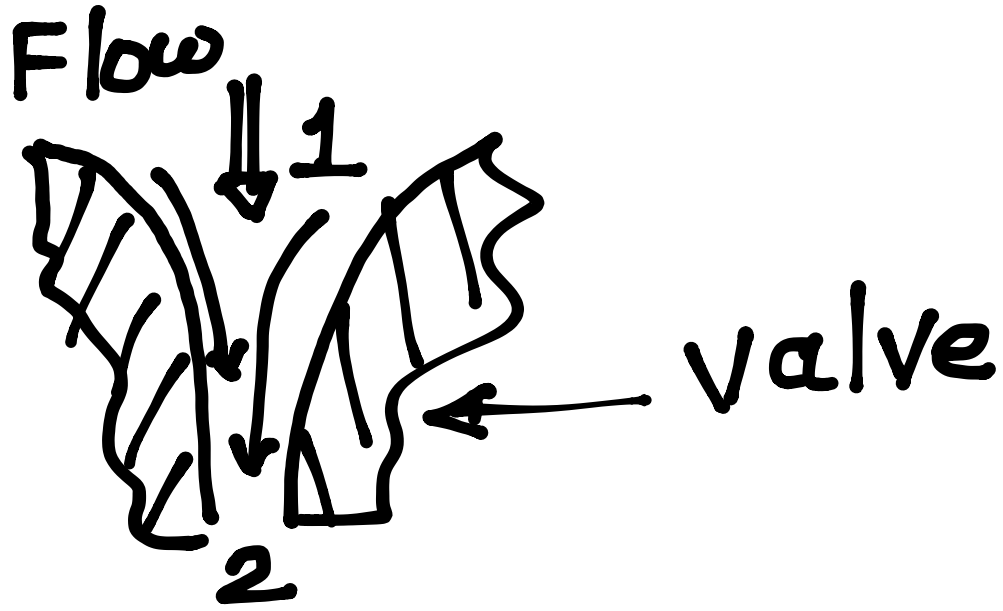
There are three valves,namely, aortic valve, tricuspid valve and mistrial valve in the heart. Pathologies of heart valves are common, affecting a fairly large percentage of the population. The problem is classified as either regurgitation or stenosis. In regurgitation, valve fails to close properly, causing the blood to flow back into the atria or ventricles.



Valve regurgitation is most common in aeortic valve followed by mistrial valve. This pathology is a result of degeneration of the aortic valve, rheumatic heart disease, bacterial endocarditis, trauma or damage to the papillary muscle connected to mistrial valve. More severe regurgitation can cause shortness of breath and palpitation.

Stenosis is a narrowing within the flow channel. Stenosis refers to a decreased area of opening of the valve. This arises from degeneration and calcification of the valve. In some cases, the aorta downstream is constricted due to congenital malfunction. Stenosis causes heart to expend more work in pumping blood through the body.

The heart compensates for narrowing by increasing its muscle mass (hypertrophy). This often leads to secondary complications. The schematic of the valve is shown below.



Bernoullis equation is given by

$$\frac{1}{2}\rho v^2 + p + \rho g z = \text{Constant along a streamline.}$$

Neglecting gravity, the above equation can be written between points 1 and 2 is given by

$$\frac{1}{2}\rho (v_2^2 - v_1^2) = (p_1 - p_2)$$

Since v1<< v2, one can write

$$(p_1 - p_2) \simeq \frac{1}{2}\rho v_2^2$$

Narrowing $\Rightarrow$ Higher v_2 for same flow rate

$\therefore$ Narrowing $\Rightarrow$ Higher $(p_1 - p_2)$

$$\text{Power} = \dot{m}\frac{\Delta p}{\rho}$$

$$\text{Power} \simeq \frac{\dot{m} V_e^2}{2}$$

Narrowing $\Rightarrow$ Higher power requirement.