Frank- starling mechanism and mechanical efficiency

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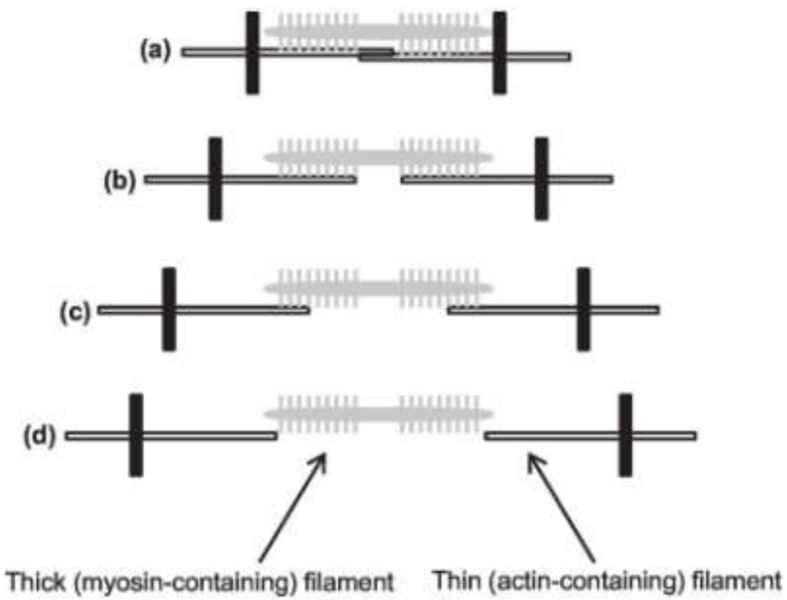
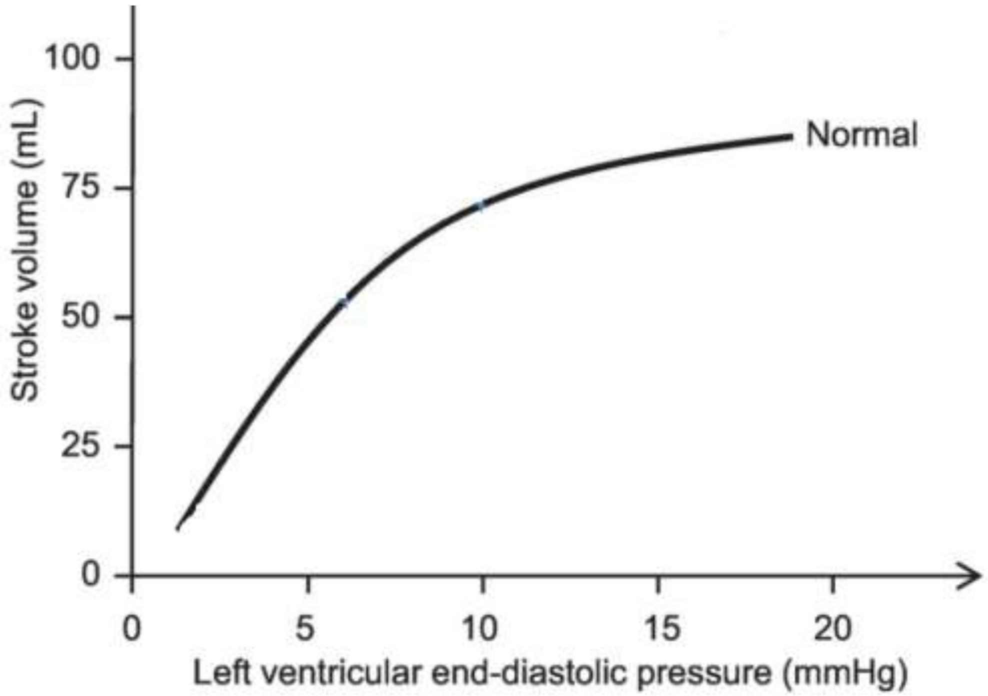
Frank starling mechanism



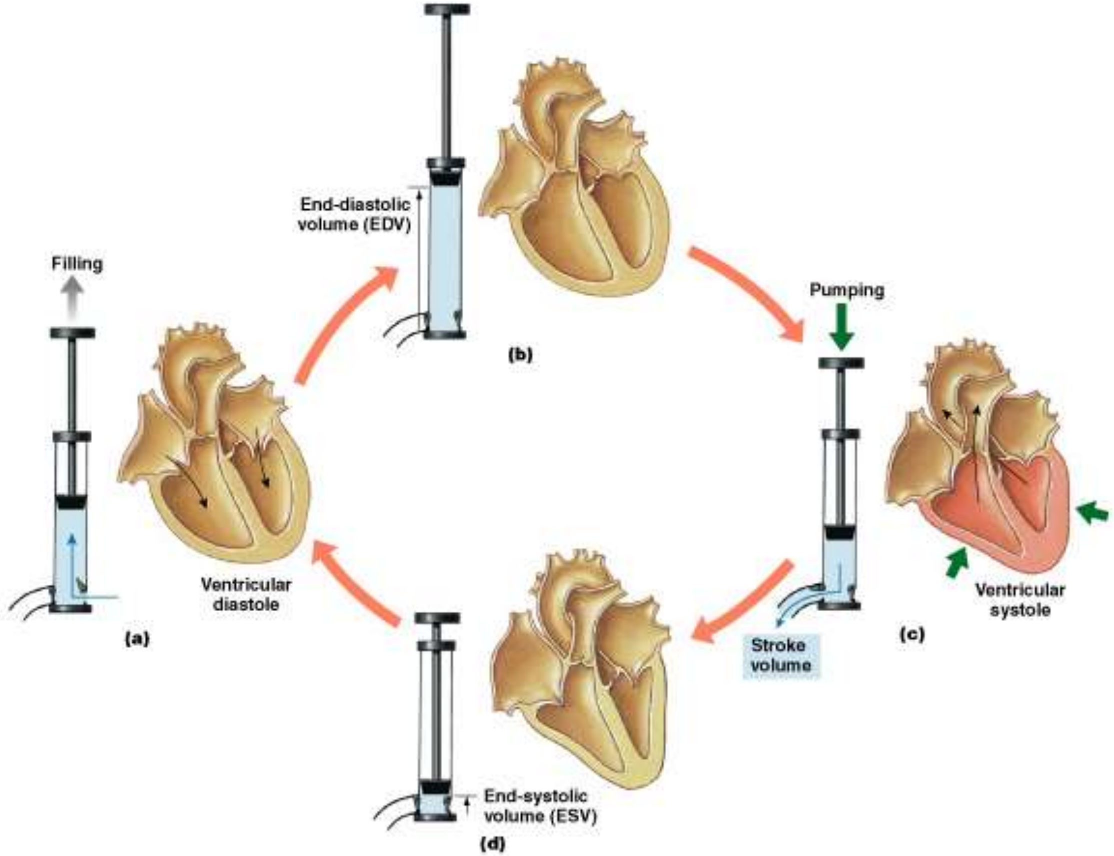
Tension developed at different cardiac sarcomere lengths.



Frank – Starling Principle

- The Frank–Starling law of the heart (also known as Starling's law and the Frank–Starling mechanism) represents the relationship between stroke volume and end diastolic pressure
- This principle illustrates the relationship between cardiac output and left ventricular end diastolic volume
- The law states that the stroke volume of the heart increases in response to an increase in the volume of blood in the ventricles, before contraction (the end diastolic volume), when all other factors remain constant.
- As a larger volume of blood flows into the ventricle, the blood stretches the cardiac muscle fibers, leading to an increase in the force of contraction.
- The Frank-Starling mechanism allows the cardiac output to be synchronized with the venous return, arterial blood supply
- The physiological importance of the mechanism lies mainly in maintaining left and right ventricular output equality
- If this mechanism did not exist and the right and left cardiac outputs were not equivalent, blood would accumulate in the pulmonary circulation (were the right ventricle producing more output than the left) or the systemic circulation (were the left ventricle producing more output than the right).

Stroke Volume(SV)



Frank – Starling Principle

- End diastolic volume: volume: The amount of blood that remains in the ventricle just before ventricular early systole is the EDV
- End systolic volume: The amount of blood that remains in the ventricle at the end of ventricular systole is the ESV

$$SV = EDV - ESV$$

Starling Forces

- Kidney net filtration favoring – opposing 10mmHg capillary and Bowman"s capsule

Capillary O2 arteriole side, CO2 to venous side

Hydrostatic capillary and oncotic interstitial favoring filtration

Oncotic capillary and hydrostatic interstitial opposing filtration

Hypoproteinemia

Nephrotic syndrome protein in urine > 300mg/day albumin, lipoprotein, anti. Thrombosis III, gout

Malnutrition

Chronic liver disease

Sever Burns

Malabsorption

Blood pressure

❖Blood pressure =cardiac output X total peripheral resistance

- $\boldsymbol{BP = \ CO\ \ X\ \ TPR}$

First, we want to decide what CO and TPR is , then we get to the right meaning of BP

❖Cardiac output (Flow)= Heart rate X Stroke volume

$\boldsymbol{CO\ (F) = \ HR\ X\ SV}$

ml/min= Beat/min X ml/ Beat

Cardia out put

- **HR**
- PSNS -
- SNS +
- Hormones (EPI, NE) +
- IONS: Ca^{++}, Na^{+} , K^{+} dependents on their level increase or decrease

SV

+ Preload ; Increase the blood volume returns increase diastolic volume

+ Contractility ; SNS (EPI,NE+), Hormones (glucagon,T3 and T4), IONS like Ca^{++}

- Afterload; Hypertension, Atherosclerotic plaques , TPR

❖Anther formula relate to CO

- 1 ml= 1 Cm3
- Flow = Cm3/min

❖Anther formula relate to flow

- Velocity (Cm2/min)= Flow (cm3/min)

  Cross sectional area (Cm2)

- **V= F/A**

❖How to relate this to cardiac output

- Increase Flow (CO)   Increase V
- Cross sectional area; measured in units of bier square because the blood vessels are cylinder in shape

A (πr2); Increase A   Decrease V

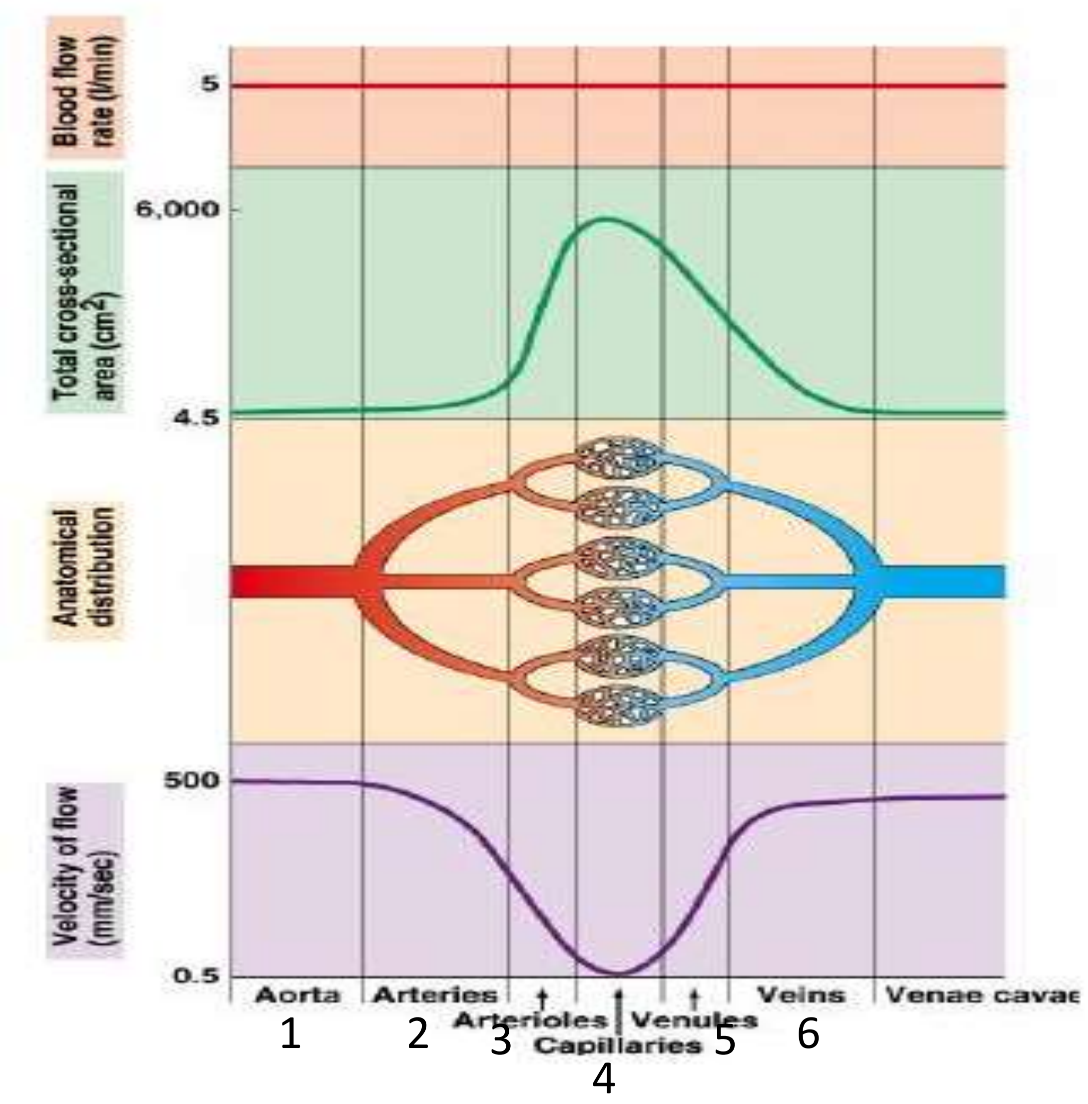
Imagine a hose and water coming out of the hose at a nice pace then I put my thumb on the edge of the hose and I make A smaller the flow of the water is going to shooting out that means the velocity increases

Velocity and cross-sectional area

- The cross-sectional area for the aorta is going to be very very small as you start to move toward arterioles to capillaries it is going to start rising
- As you get towards the venules it starts decreasing again and comes back down
- You have noticed so far that the aorta and arteries don't change much they change a just little bit
- But once you hit the arterioles that's when the actual specifically the cross-sectional area increases

<u>But we have said that the aorta has a vey big diameter??</u>

- We are going to compare between each one of theses vessels
- We are going to take these numbers and correlate what we are going to talk in the next slide



Continued Cross – sectional area and velocity

- *This big one here is aorta (1) then the aorta splits it gives off arteries (2) then arterial branches (3) and then capillary branches ten to hundred per capillary bed (4) and after drain from the capillary bed then they go to what called venules (5) and from the venules they come eventually into the veins (6) and again to vena cava system*
- *compare the cross sectional are the capillary and cross-sectional area aorta and velocity*
- *As you increase the cross-sectional area the velocity decrease*
- *The velocity is the slowest in the capillaries and faster in the aorta*