CVS Block
Venous Return &
Factors Affecting it

(Physiology L No.7)

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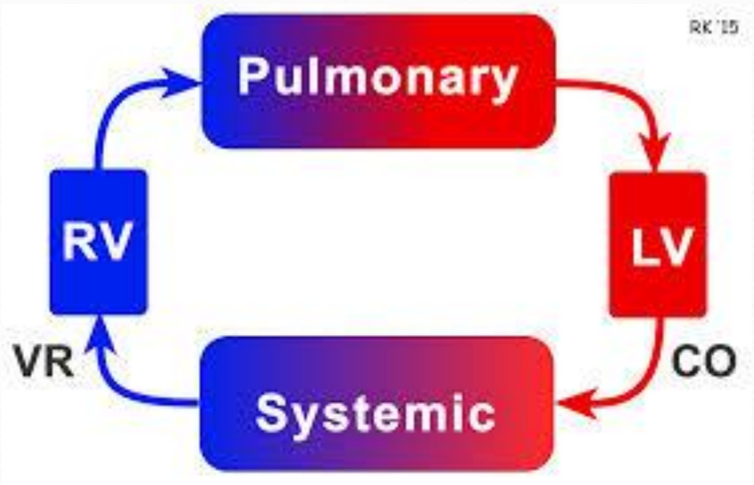
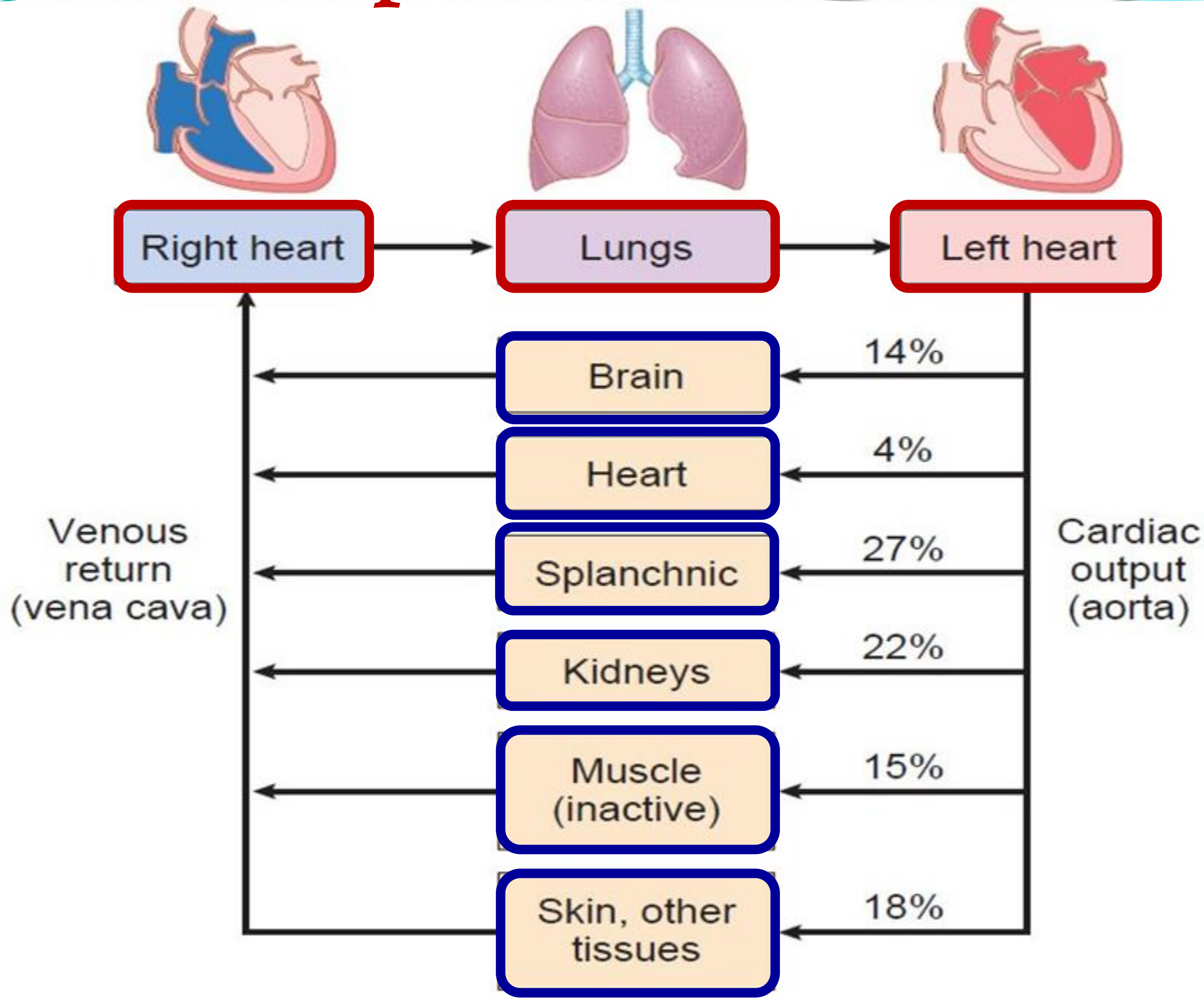


Learning Objectives

- Discuss functions of the veins as blood reservoirs.
- Know the pressure variations in systemic blood vessels.
- Define venous return, mean circulatory filling pressure and right atrial pressure.
- Describe measurement of central venous pressure (CVP) and state its physiological and clinical significance.
- Describe vascular and cardiac function curves.
- State determinants of venous return and explain how they influence it:-

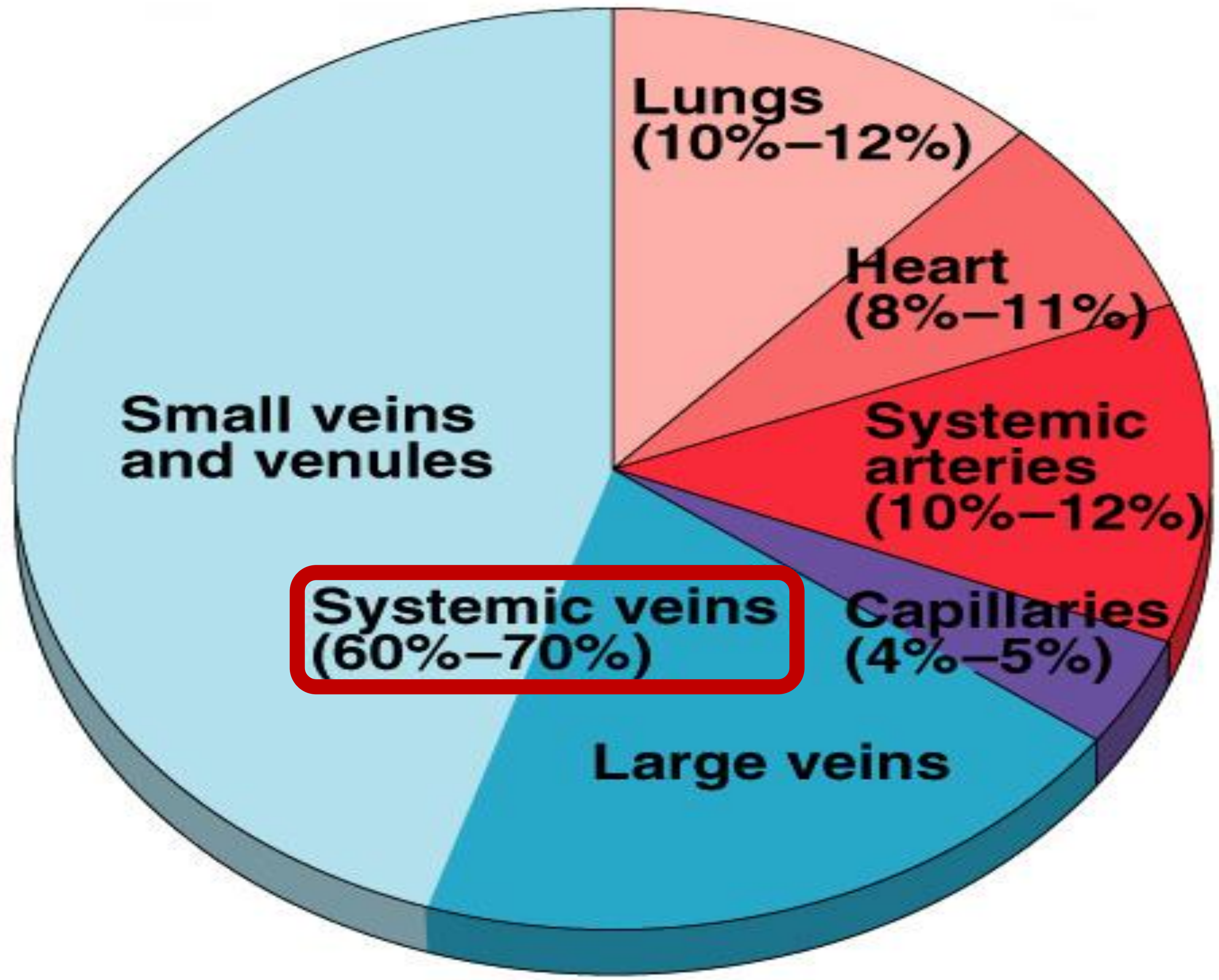
1- Pressure gradient	2- Blood volume	3- Vascular capacity
4- Sympathetic activity	5-Total peripheral resistance	6- Venous valves
7- Skeletal muscle pumps.	8- Respiratory activity	9- Gravity

Cardiac Output= Total Tissue Blood Flow



What is about the veins?

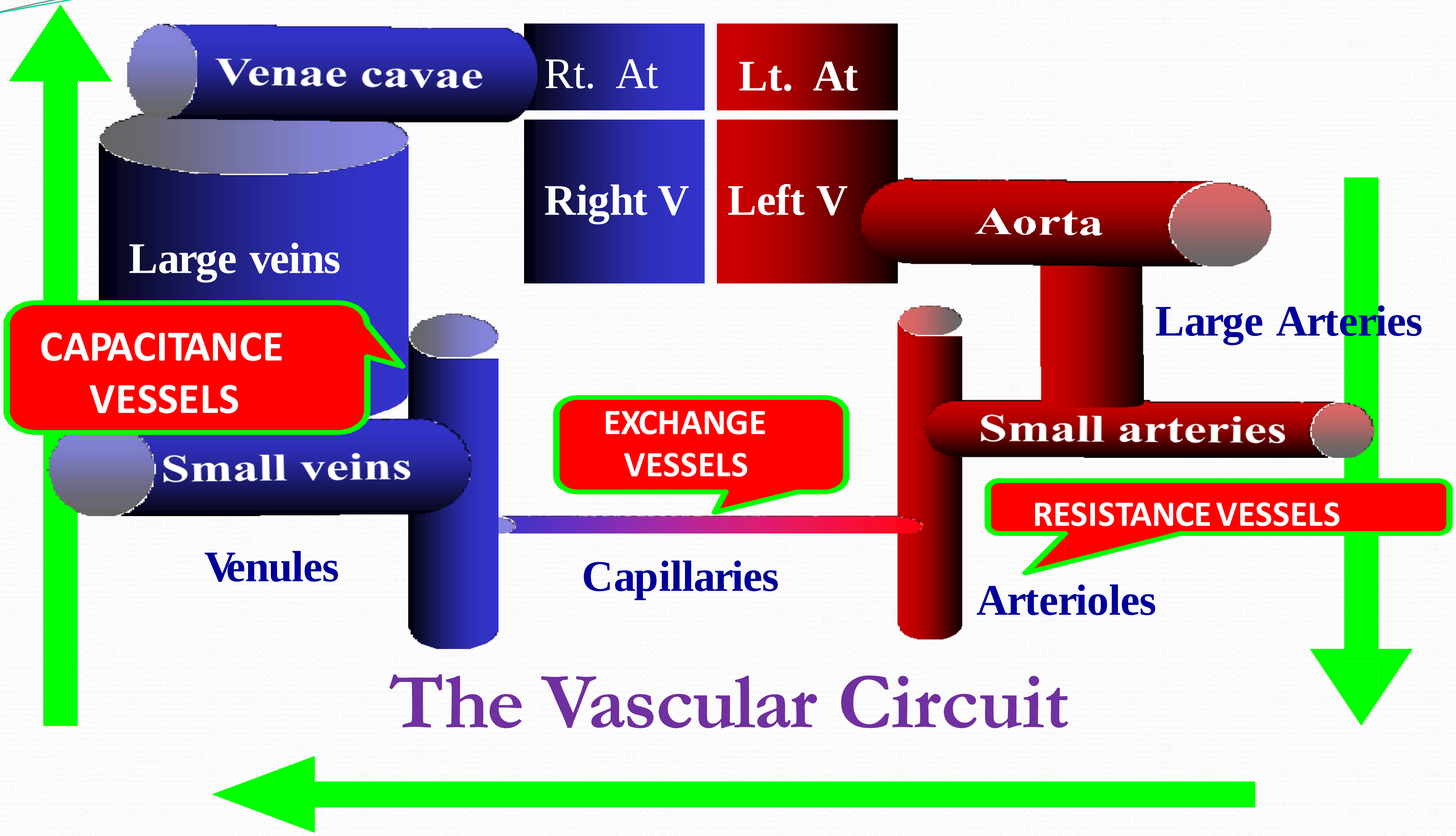
- Veins hold most of blood in body (60-70%).
- They are called capacitance vessels
- They have thin walls & stretch easily to accommodate more blood without increased pressure (= higher compliance)
- They have only 0 -10 mm Hg pressure.



Distribution of Blood

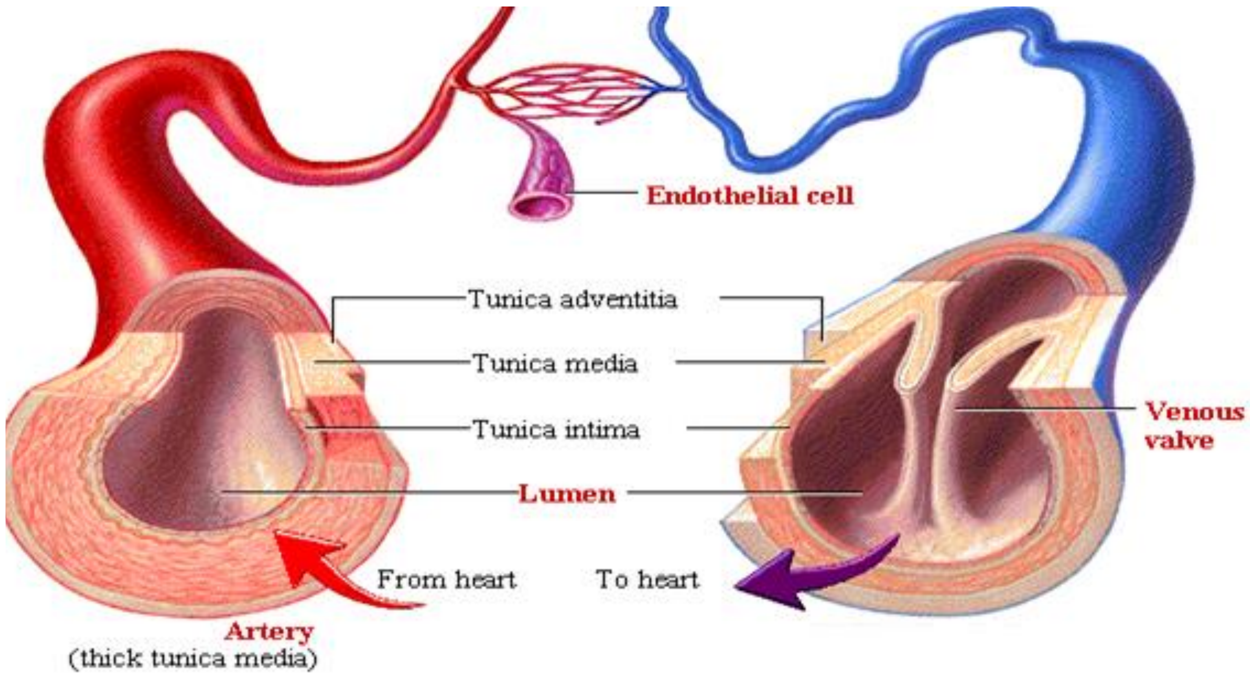
Veins Are Blood Reservoirs

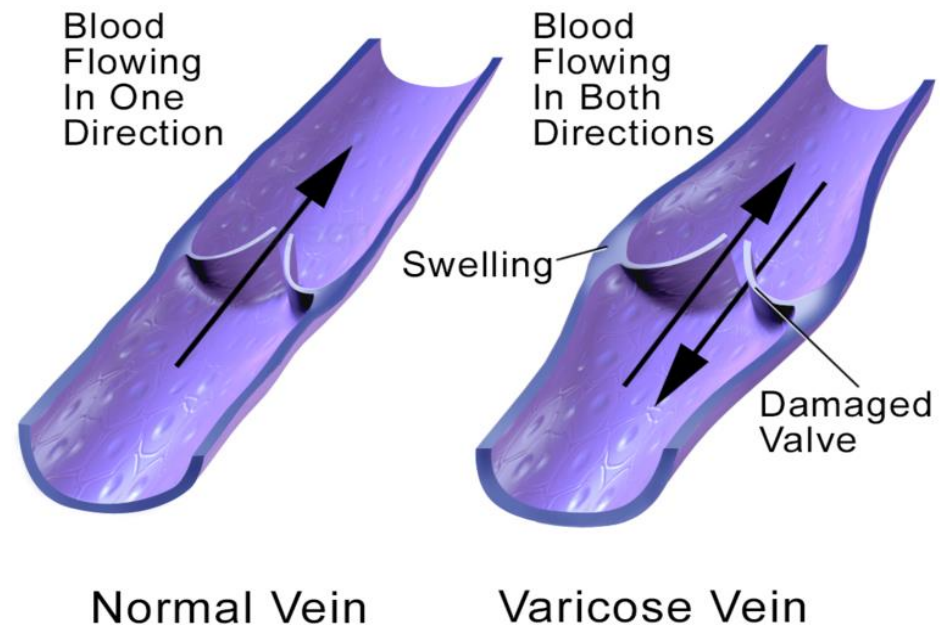
- At rest many of the capillaries are closed, the capacity of the venous reservoir ↑as extra blood bypasses the capillaries and enters the veins → stretches the veins
- Stretches of veins → ↑their total cross sectional area → blood moves forward through the veins more slowly. Therefore, blood spends more time in the veins.
- During exercise, when the stored blood is needed, extrinsic factors reduce the capacity of the venous reservoir and drive the extra blood from the veins to the heart so that it can be pumped to the tissues.



The Vascular Circuit

Structures of Veins

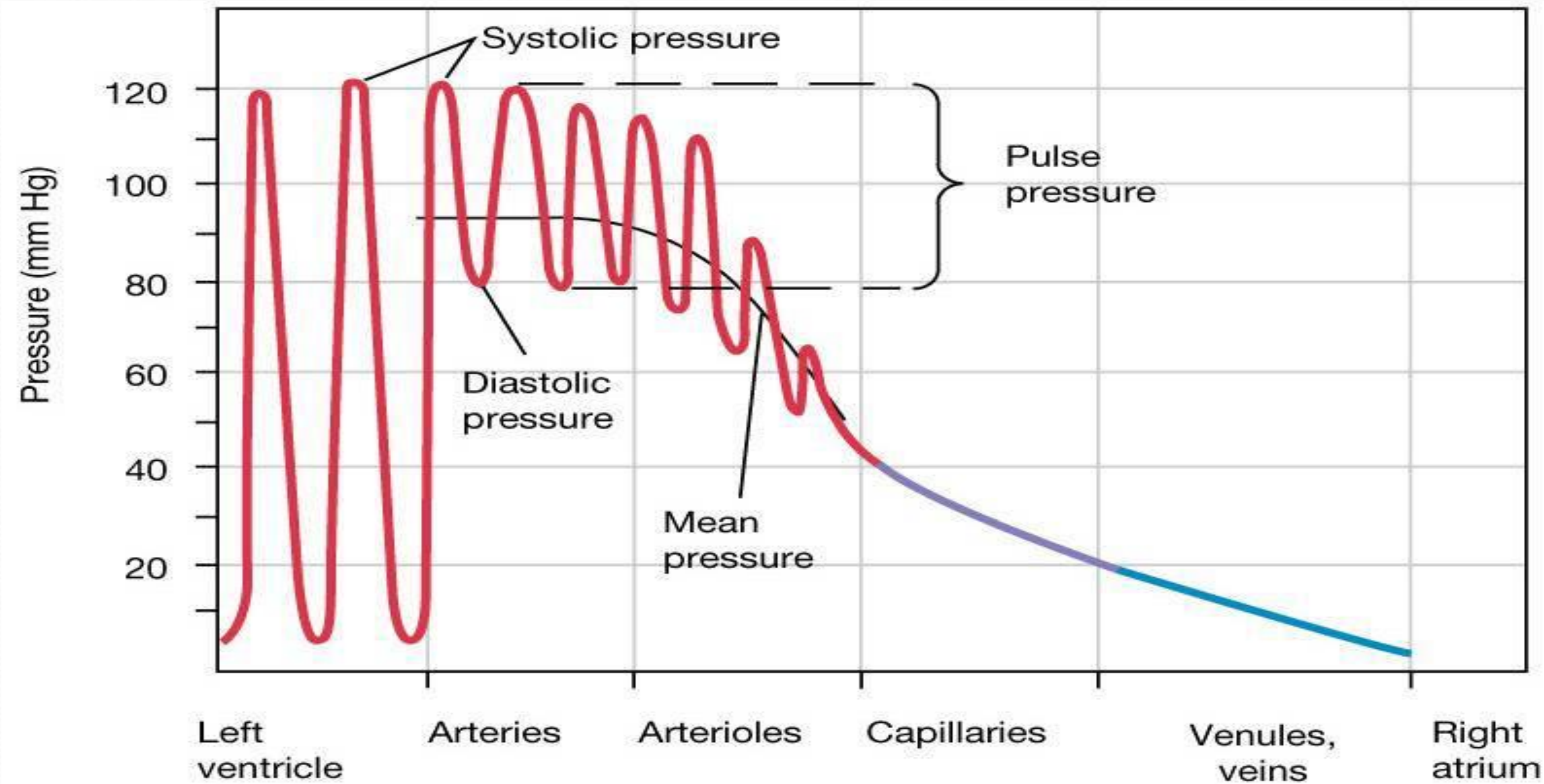




- All 3 layers are present, but thinner than in arteries of corresponding size (external diameter).
- Veins in lower extremities have paired semilunar, bicuspid valves to restrict backflow.

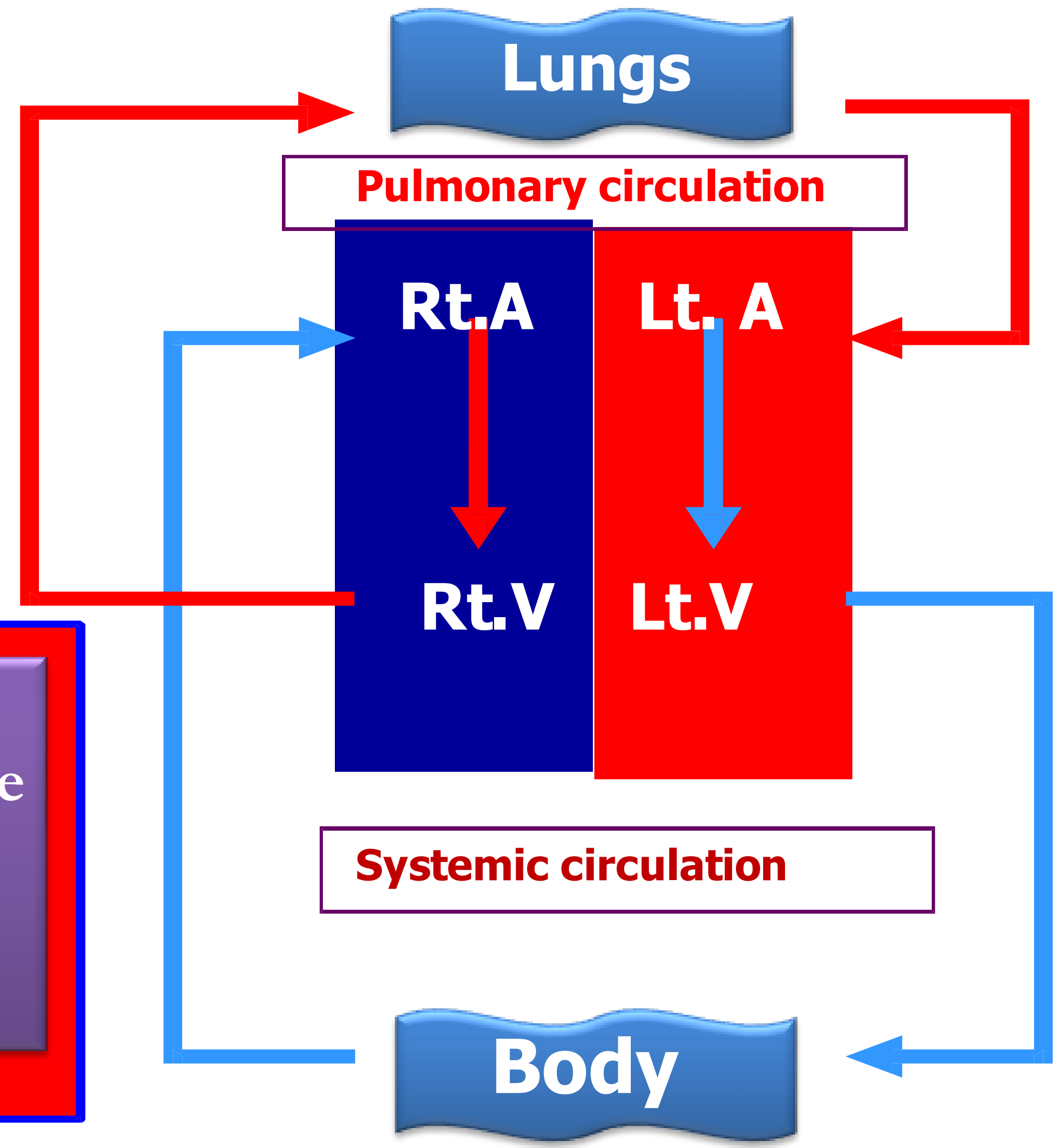
In varicose veins, blood pools because valves fail causing venous walls to expand.

Pressure Variations in Systemic Blood Vessels



VENOUS RETURN (VR)

Normally VR must equal CO when averaged over time because the CVS is essentially a closed loop. Otherwise, blood would accumulate in either the systemic or pulmonary circulations.

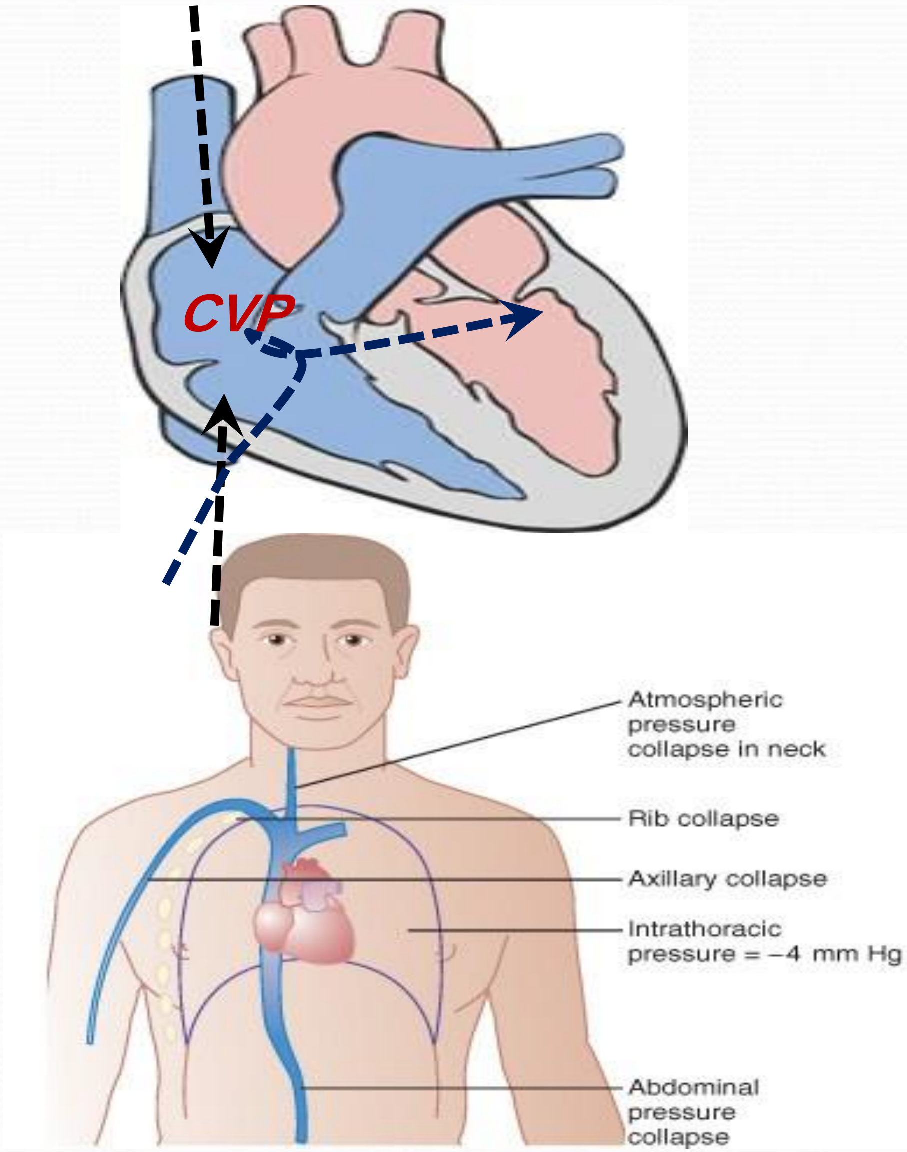


VR is determined by the difference between the venous pressure nearest to the tissues (mean circulatory pressure; MCP) and the venous pressure nearest to the heart (CVP).

VR = MCP – CVP

Central Venous Pressure (CVP)

- ***CVP:*** is the pressure in the right atrium and the big veins of thorax {right atrial pressure (RAP) = jugular venous pressure}.
- CVP is measured with a catheter inserted in SVC.
- The normal range of the CVP = 0-4mmHg.
- It is the force responsible for cardiac filling.
- CVP is used clinically to assess hypovolaemia and during IV transfusion to avoid volume overloading.
- CVP is raised in right-sided heart failure.

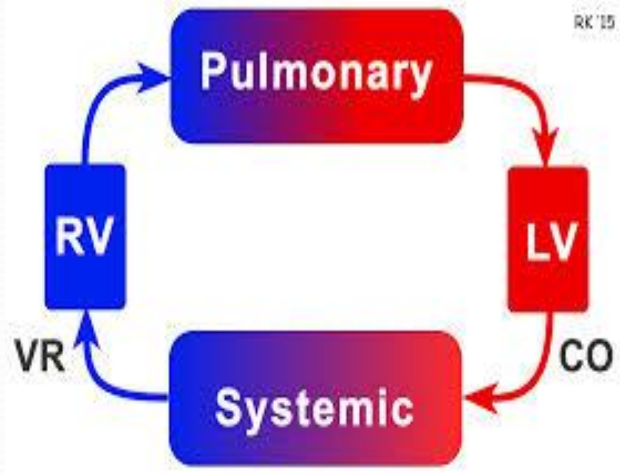


Mean Circulatory Pressure (MCP)

- It is the pressure nearest to the tissues.

IT IS AFFECTED BY:

- Blood volume:- it is directly proportional to blood volume.
- Venous capacity:- it is inversely proportional to the venous capacity.



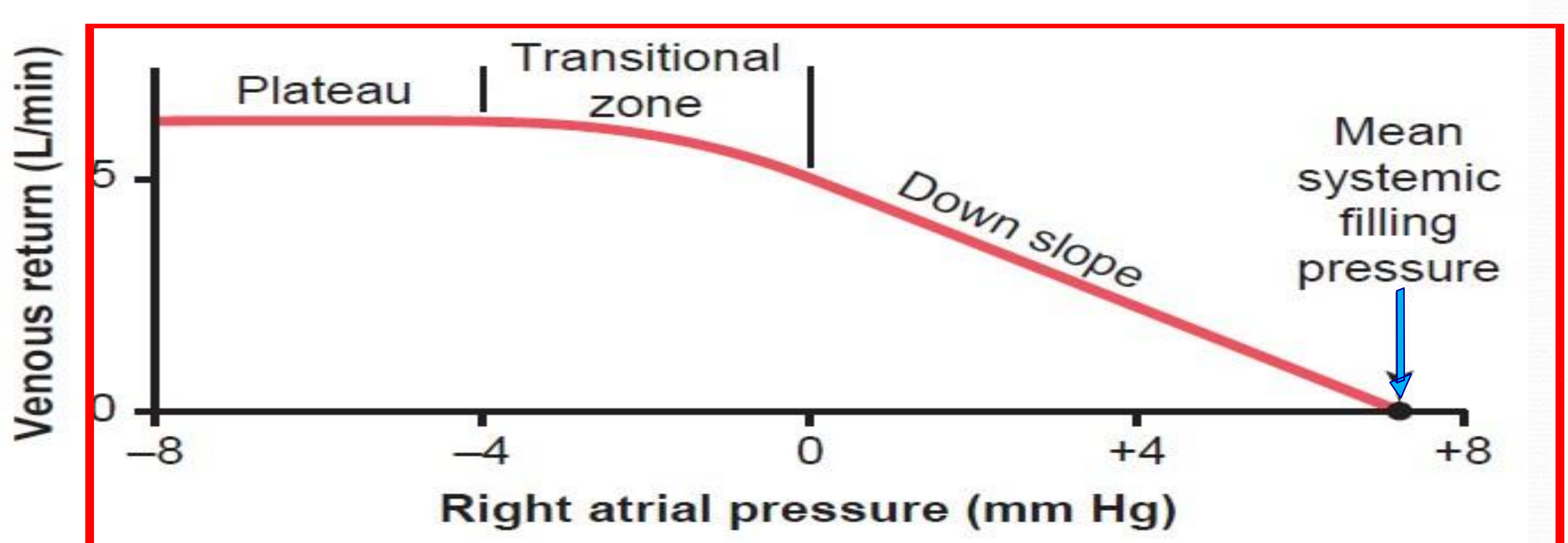
↑ Blood volume → ↑ MCP

↓ Blood volume → ↓ MCP

Venoconstriction →↑ MCP

Venodilation →↓ MCP

The Venous Return Curve
(The Vascular Function Curve)

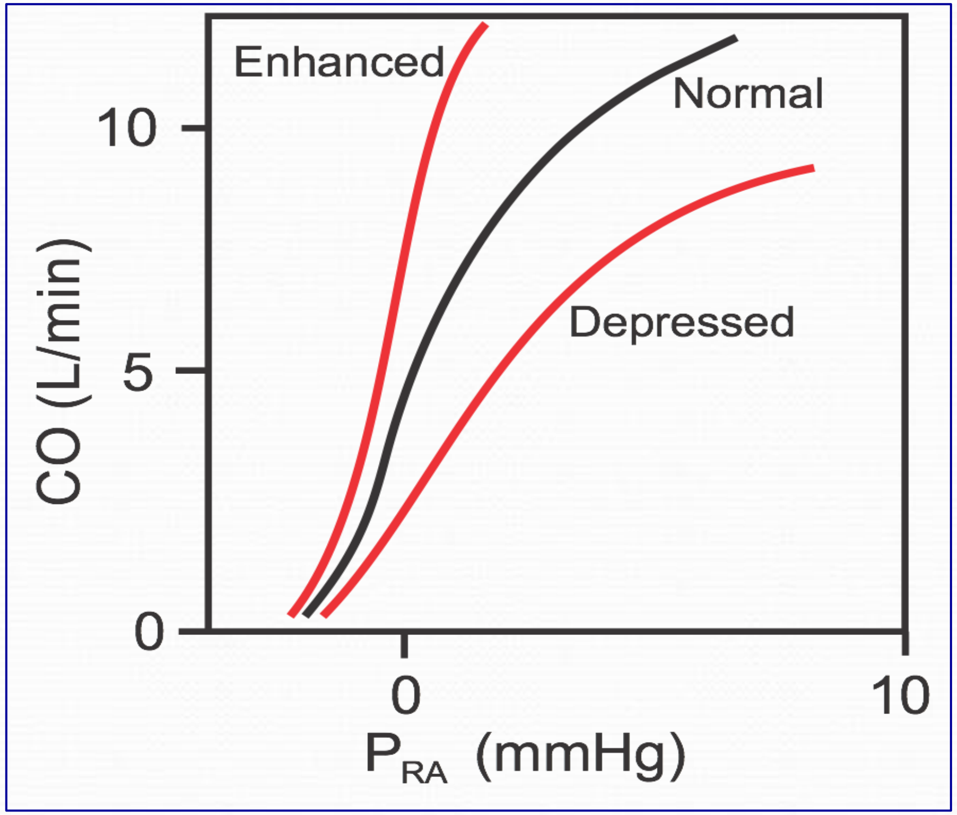


The curve relates VR To Right Atrial Pressure (RAP).
Mean systemic filling pressure (Psf) is the point at which the vascular function curve intersects the X-axis (i.e VR is zero and RAP is at its highest value, Psf =7 mm Hg).

Cardiac Function Curve

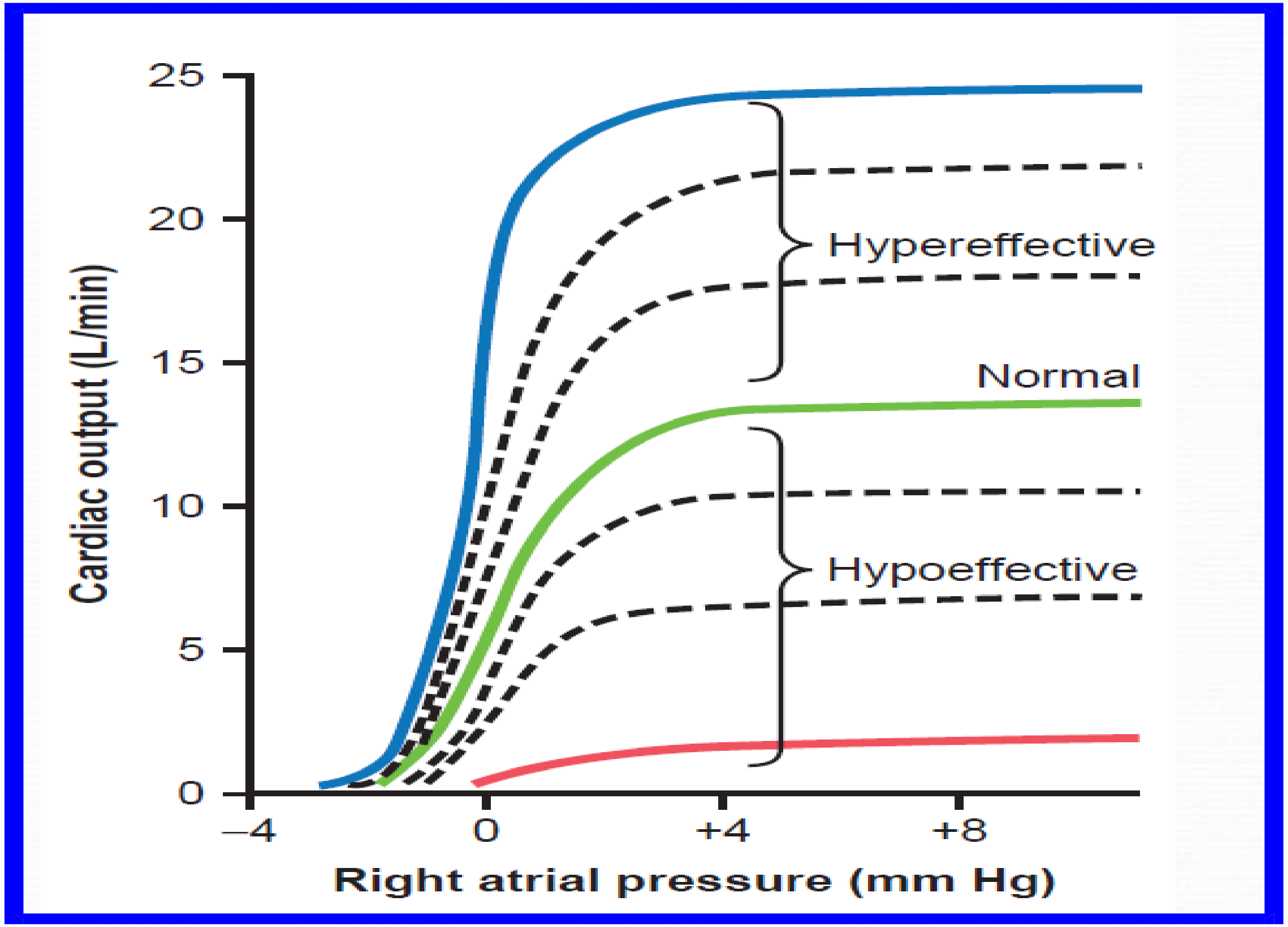
It relates pumping of blood by the heart to RAP

- The curve relates CO To Right Atrial Pressure (RAP).
- When the mean RAP is about 0mmHg, the CO in an adult is about 5L/min.
- Normally, Rt atrial pressure (RAP) fluctuates with atrial contraction and respiration.

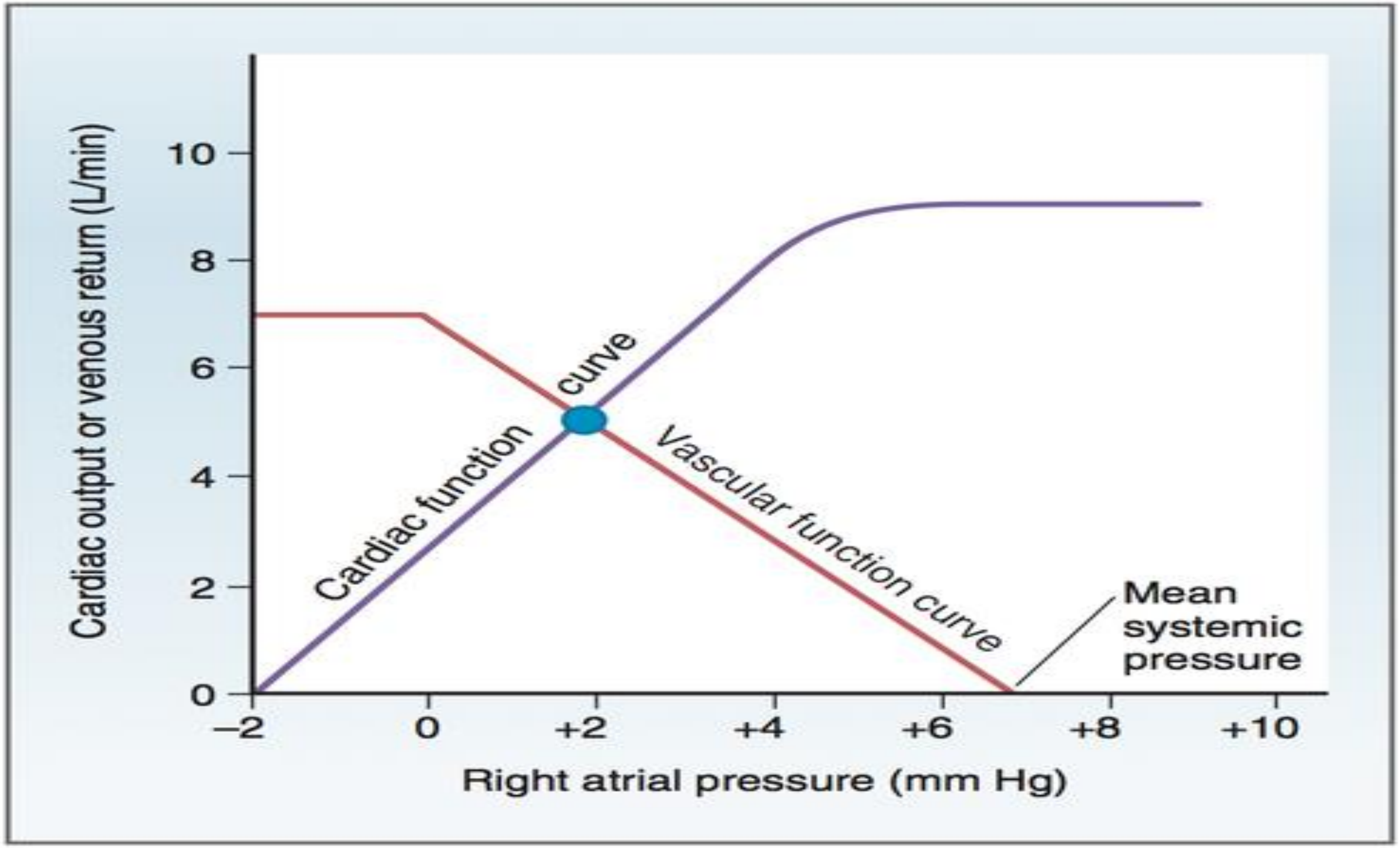


Effect of RAP Changes on Cardiac Function Curve

- Because of the steepness of the cardiac function curve, very small changes in RAP (just a few mmHg), can lead to large changes in cardiac output.

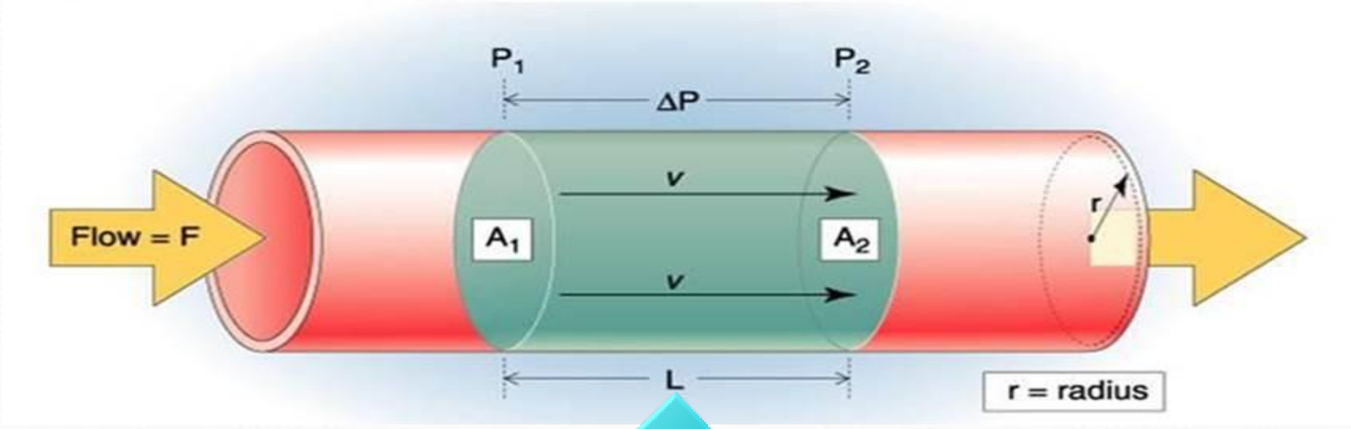


Cardiac Function Curve & Vascular Function Curve



Basic Principles

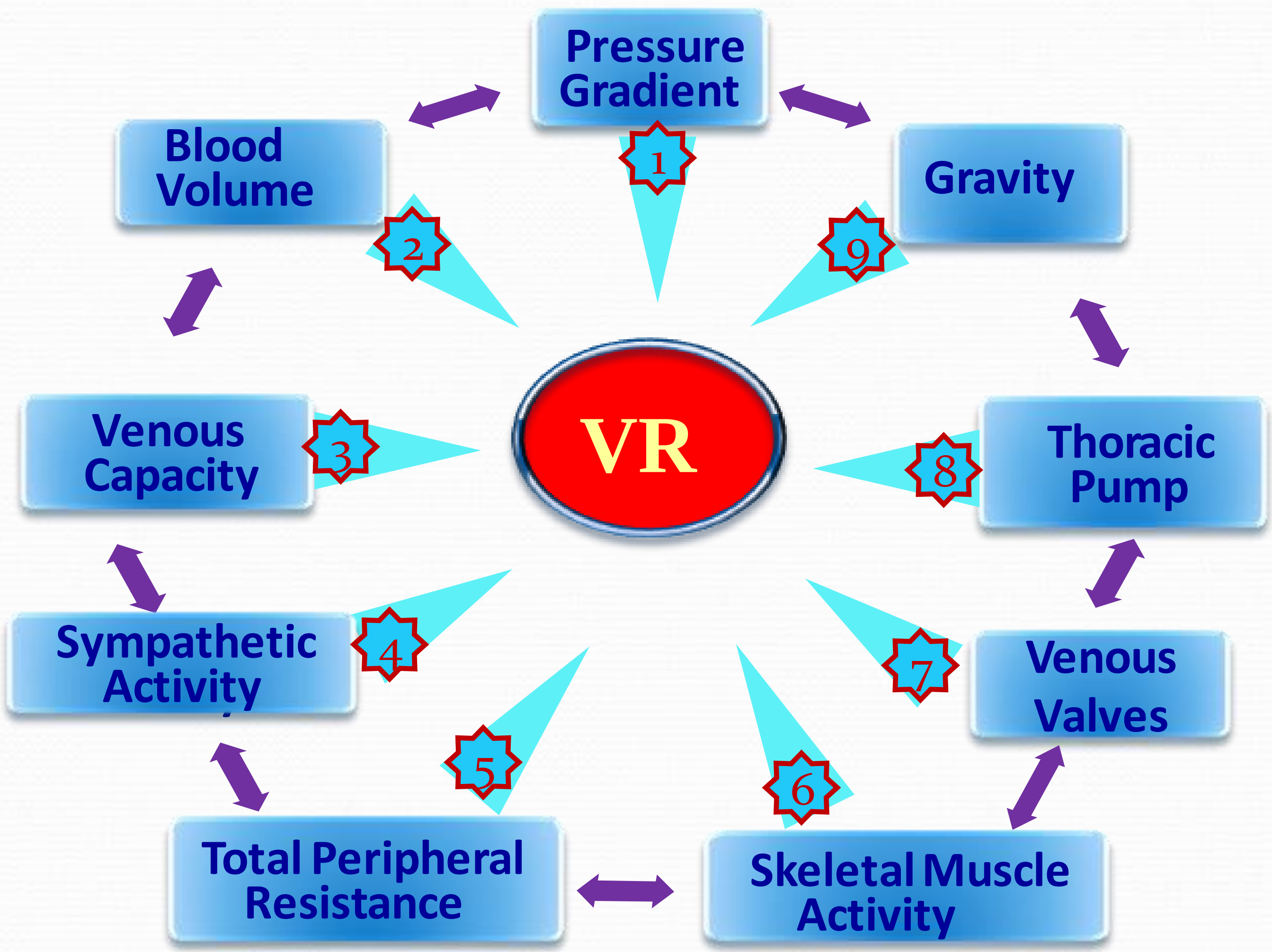
Flow of any fluid (blood) through a tube (vessel) depends on:-



- The pressure difference between the two ends *(Pressure gradient)*
- Blood flows from *high* pressure to *low* pressure

- The resistance to blood flow through the vessel
- Controlled by the diameter of the vessel

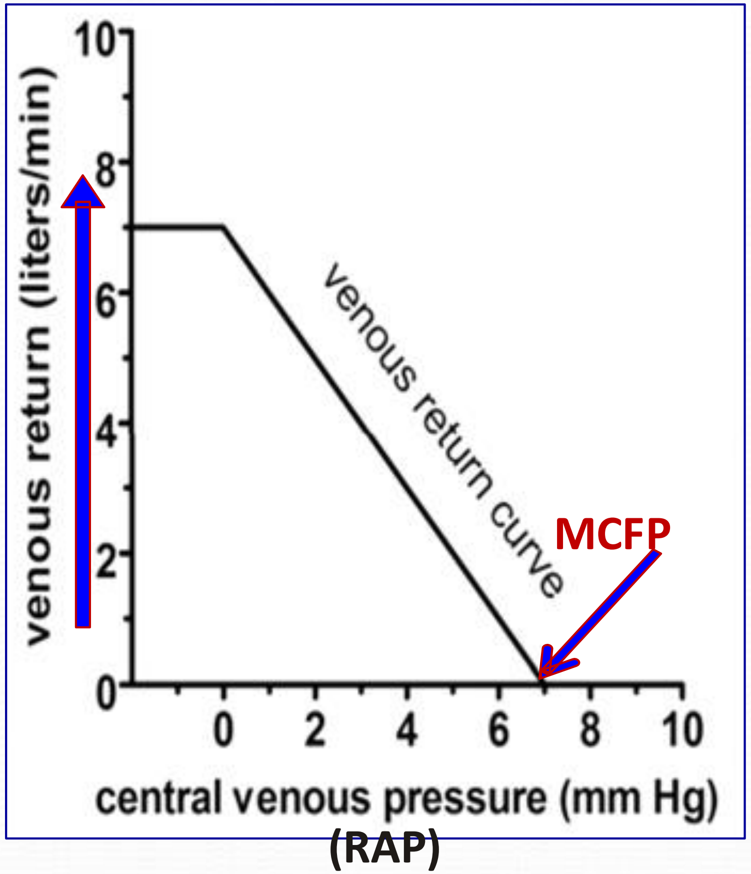
Determinants of Venous Return



Determinants of Venous Return

1-Pressure gradient

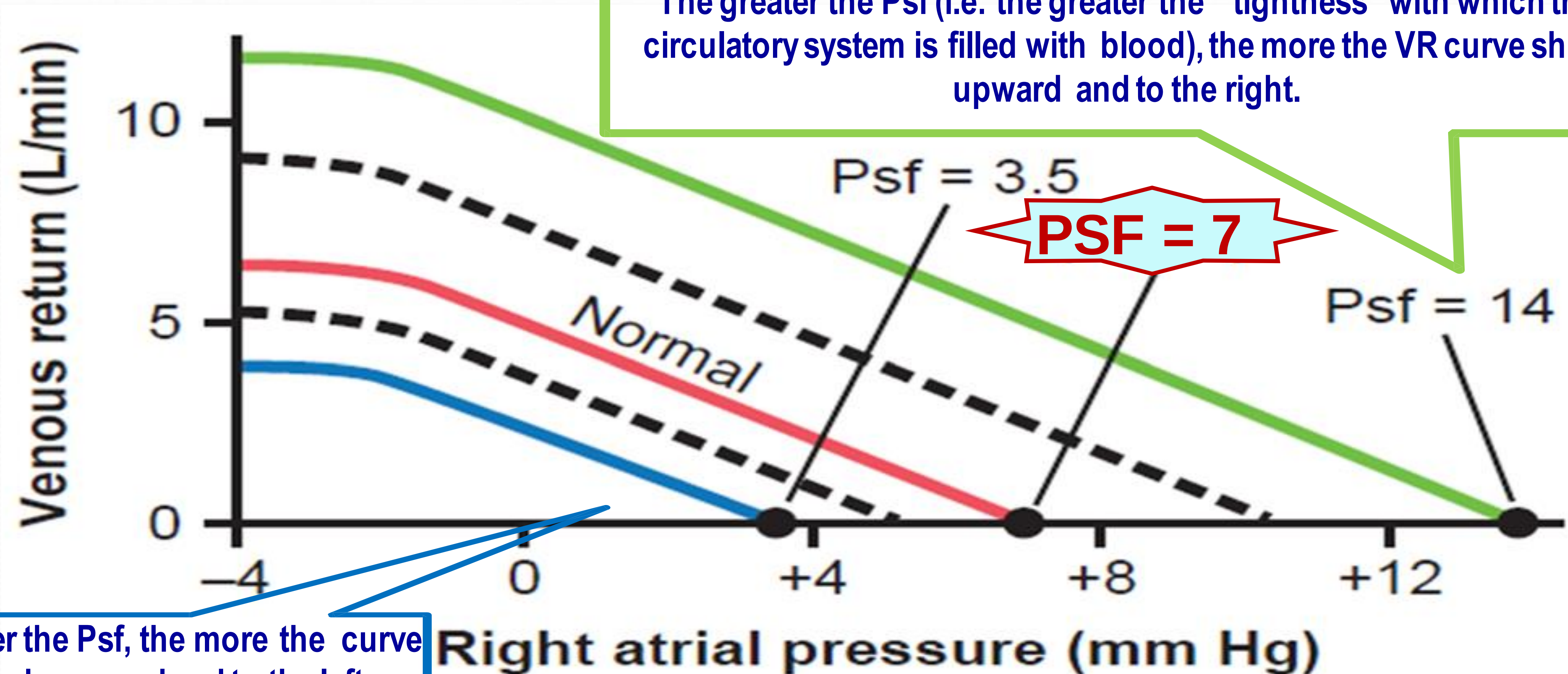
- VR back to the heart is driven by a pressure gradient. VR= MCP - RAP (CVP)
- There is an inverse relationship between VR and RAP (CVP).
- The lower the RAP, the higher the pressure gradient and the greater the VR.
- Thus as RAP ↑, pressure gradient ↓ and VR also ↓.
- When the RAP falls below zero (i.e at negative values of RAP., no further increase in VR and a plateau (the knee, flat portion) is reached.
- Cause: collapse of the veins entering the chest. This impedes VR inspite of high pressure gradient.



The greater the difference between the mean circulatory filling pressure (psf) and the RAP, the greater becomes the VR

When the RAP = Psf, there is no longer any pressure difference between the peripheral vessels and the Rt atrium. Resulting in ???

The greater the Psf (i.e: the greater the "tightness" with which the circulatory system is filled with blood), the more the VR curve shifts upward and to the right.



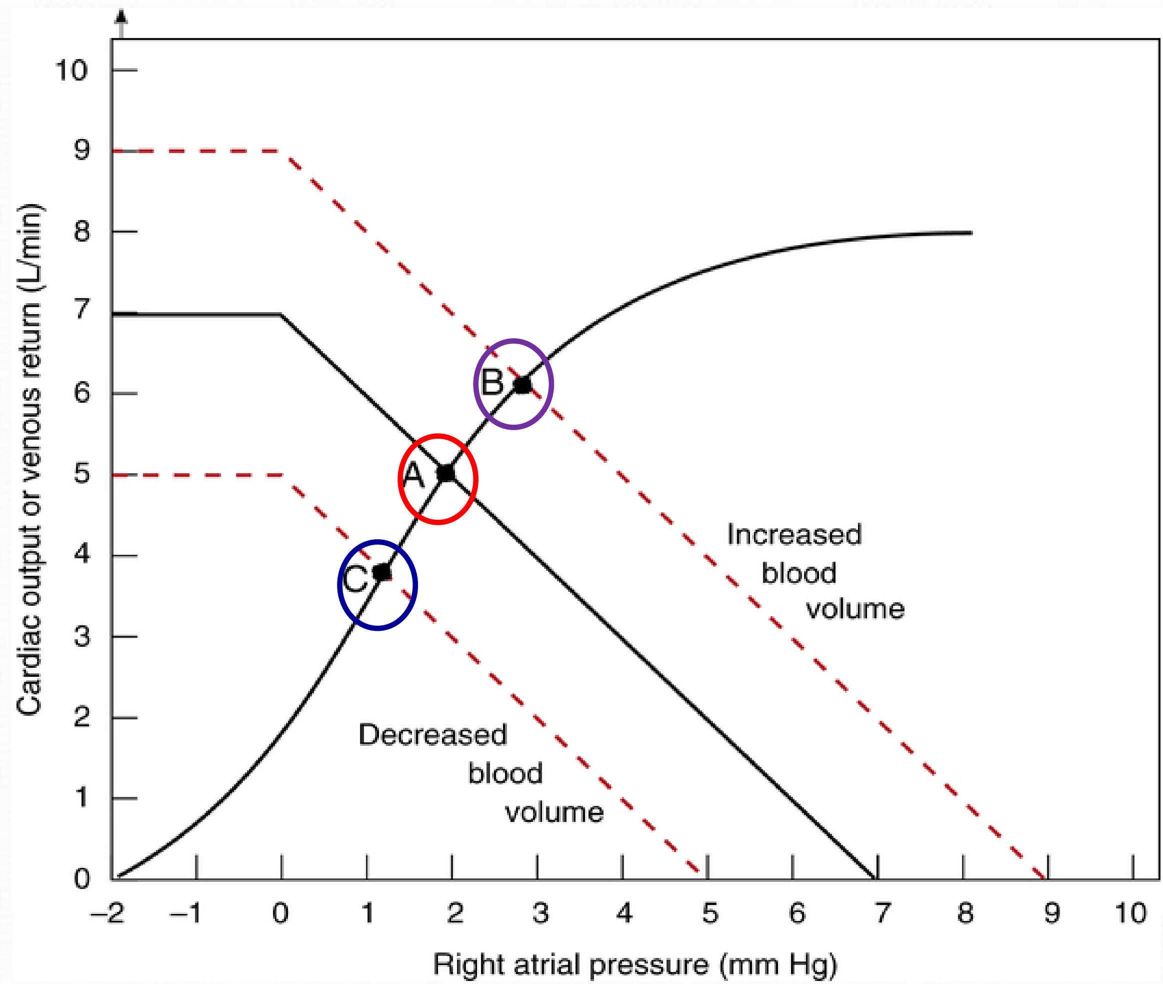
The lower the Psf, the more the curve shifts downward and to the left.

Determinants of Venous Return (Cont.)

2- Blood volume

At constant venous capacity,

- ↑ blood volume → ↑ MCP → ↑ VR, i.e: The intersection point of the vascular function curve shifts upwards and to the right (point B).
- ↓ blood volume → ↓ MCP → ↓ VR, i.e: The intersection point of the vascular function curve shifts downwards and to the left (point C).

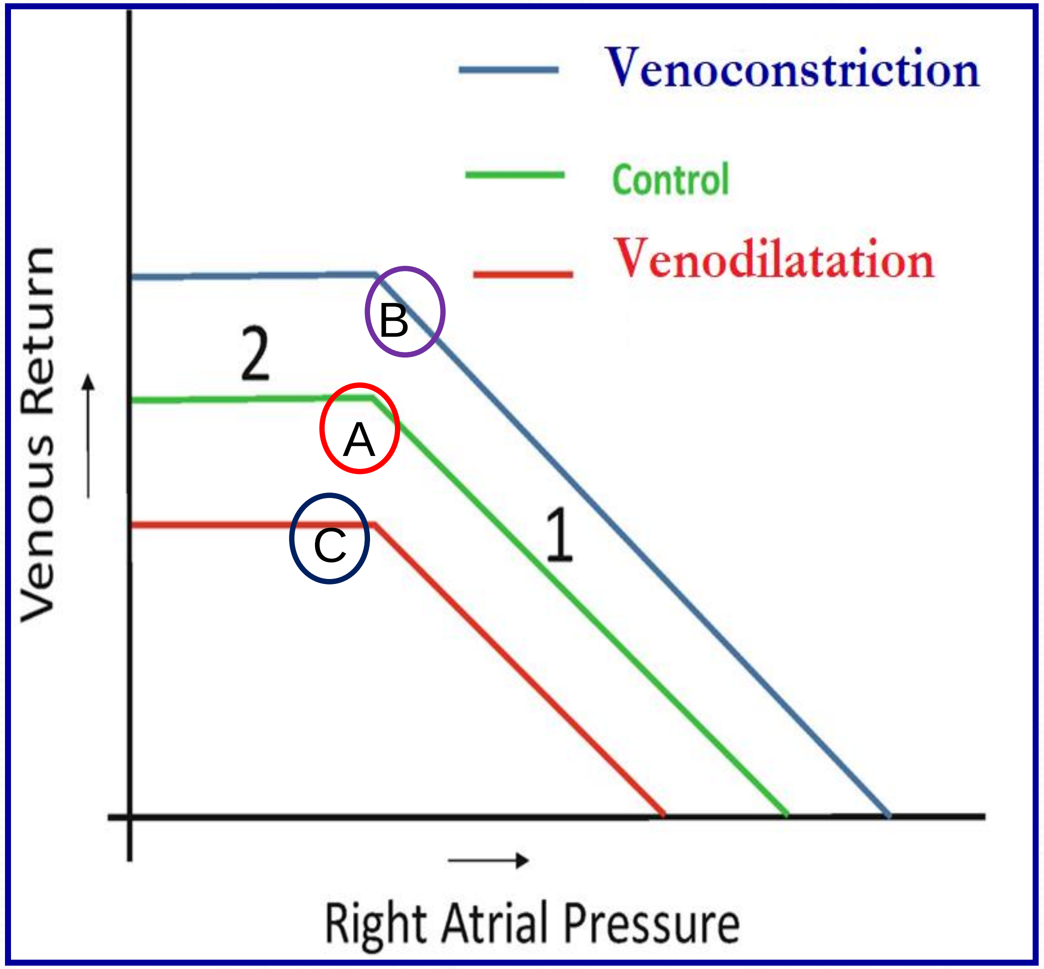


Determinants of Venous Return (Cont.)

3- Venous capacity

At a constant blood volume,

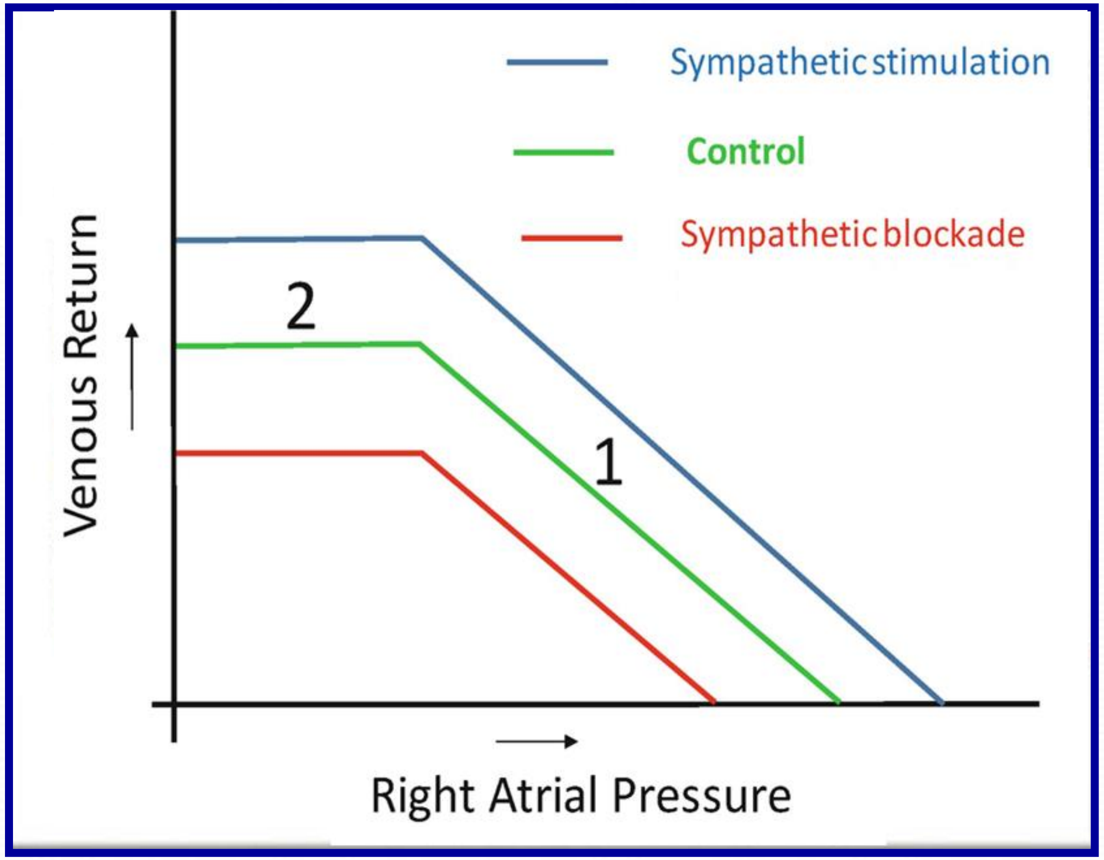
- ↓ venous capacity (venoconstriction) → ↑ MCP → ↑ VR, i.e: The intersection point of the vascular function curve shifts upwards and to the right (point B).
- ↑ venous capacity (venodilation) → ↓ MCP → ↓ VR, i.e: The intersection point of the vascular function curve shifts downwards and to the left (point C).



Determinants of Venous Return (Cont.)

4. Sympathetic activity:

- Venous smooth muscle is profusely supplied with sympathetic fibers.
- ↑ Sympathetic nervous system (SNS) activity → venoconstriction →↓ venous capacity → modest ↑ MCP → ↑ VR.
- The veins normally have such a large diameter that the moderate vasoconstriction accompanying sympathetic stimulation has little effect on resistance to flow.



Determinants of Venous Return (Cont.)

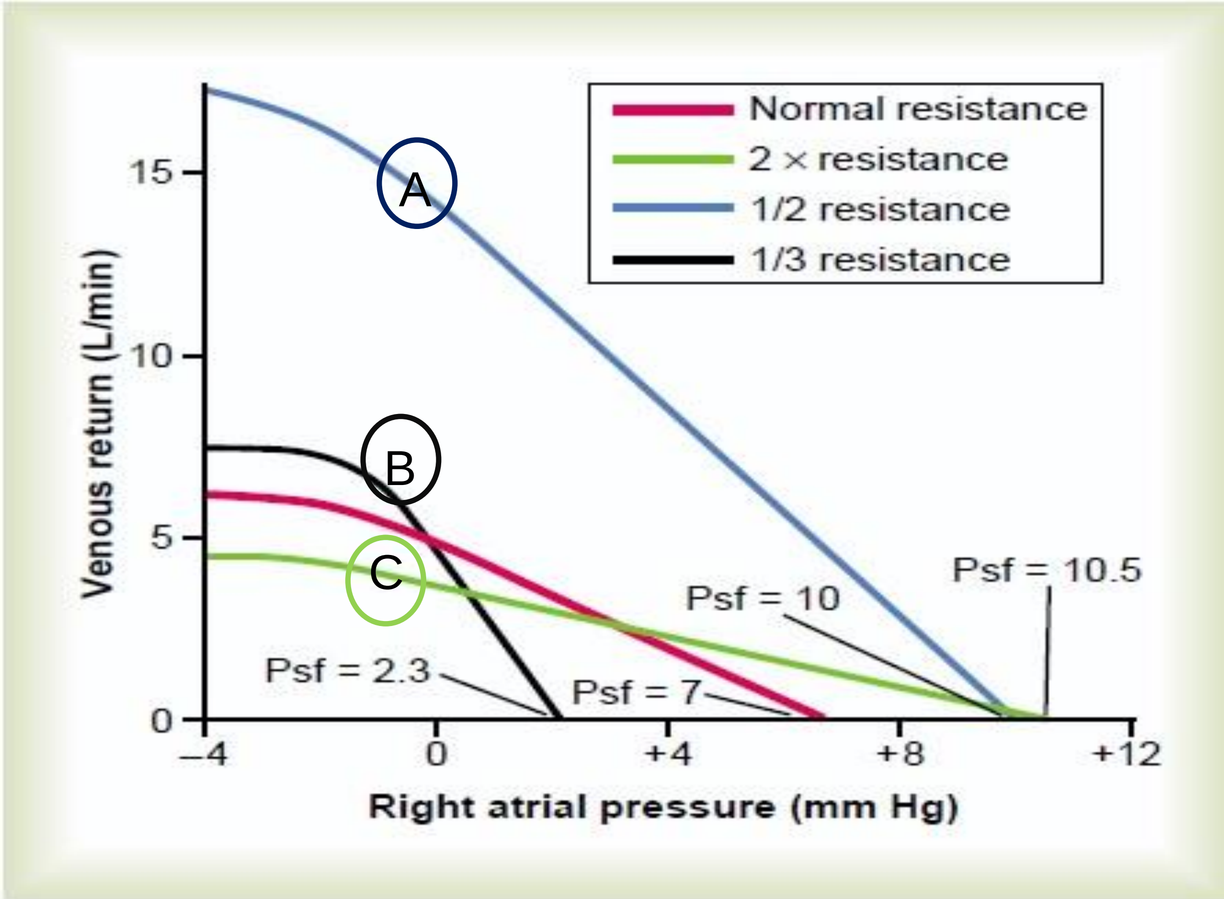
5- Total peripheral resistance (TPR)

Vasoconstriction → ↑ TPR → ↓ VR

For a given RAP:

- ↓ **TPR** → ↑ **VR** (points A ,B), i.e: decreased resistance of the arterioles makes it easier for blood to flow from the arterial to the venous side of the circulation and back to the heart.

- ↑ **TPR** → ↓ **VR** (point C), i.e: increased resistance of the arterioles makes it more difficult for blood to flow from the arterial to the venous side of the circulation and back to the heart.



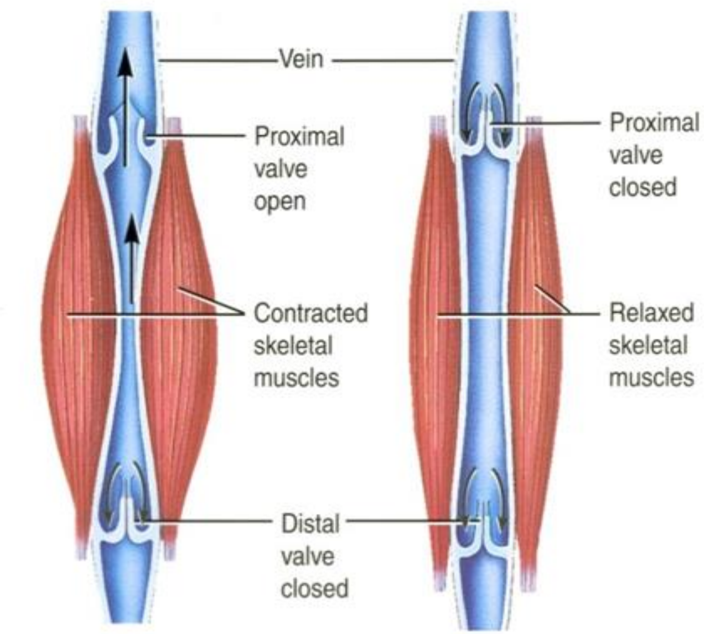
Determinants Of Venous Return (Cont.)

6. Skeletal muscle activity:

- Skeletal muscle contraction → external venous compression → ↓ venous capacity → ↑ VR (This is known as skeletal muscle pump).

- Skeletal muscle activity also counter the effects of gravity on the venous system.

Skeletal muscle pump enhancing venous return

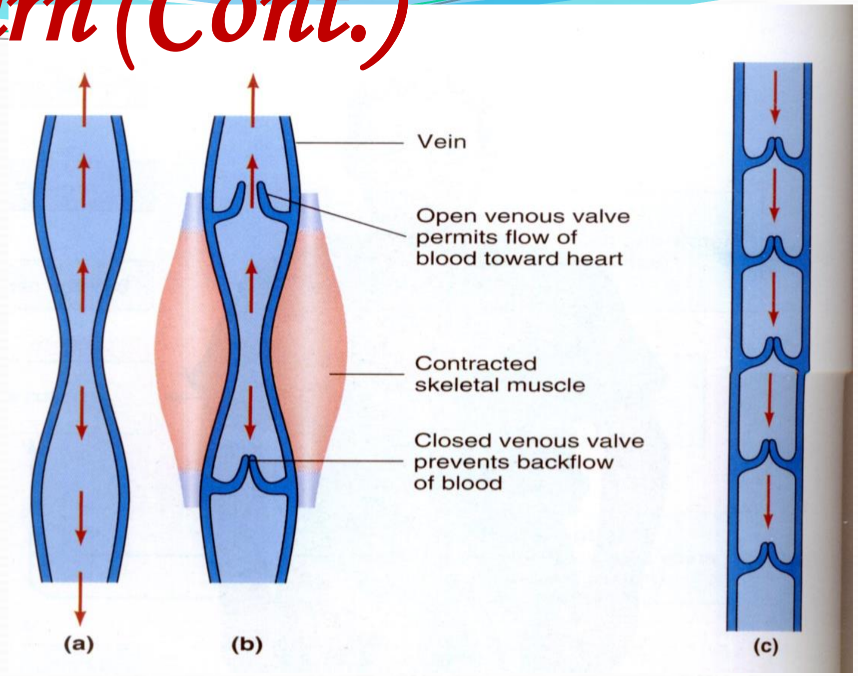


(a) Contracted skeletal muscles (b) Relaxed skeletal muscles

Determinants of Venous Return (Cont.)

7. Venous valves:

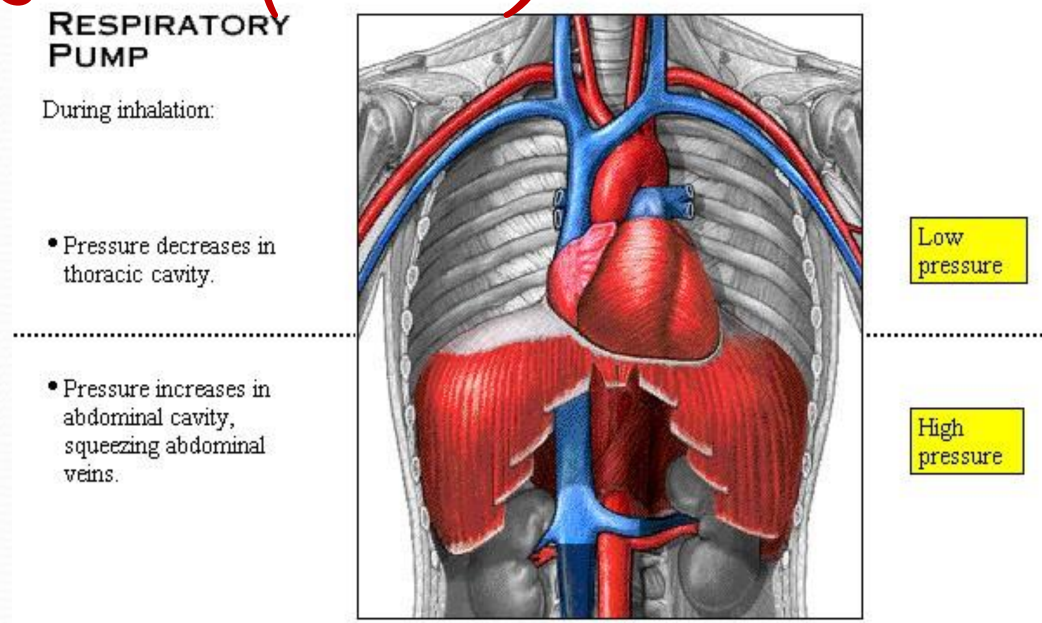
- The valves permit blood to move forward towards the heart but prevent it from moving back toward the tissues.
- The valves also play a role in counteracting the gravitational effects of the upright posture.
- Skeletal muscle pump is ineffective when the venous valves are incompetent.
- Chronically raised pressure in the veins leads to pathological distension of the veins (varicose veins).
- Increased capillary filtration leads to swelling (edema) with trophic skin changes and ulceration (venous ulcers).



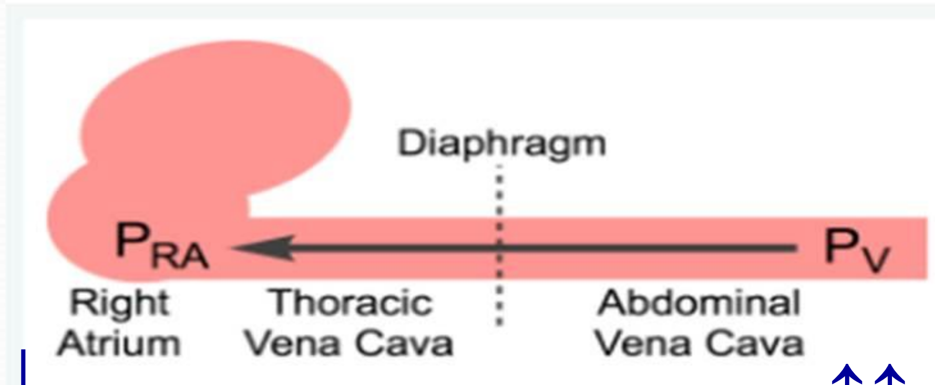
Determinants of Venous Return (Cont.)

8. Respiratory activity (respiratory or thoracic pump):

- As the venous system returns blood to the heart from the lower regions of the body, it travels through the chest cavity .
- The pressure in the chest cavity is 5mmHg less than atmospheric pressure.
- The venous system in the limbs and abdomen is subjected to normal atmospheric pressure.
- Thus, an externally applied pressure gradient exists between the lower veins and the chest veins, promoting VR (respiratory pump).



Negative intrathoracic pressure Increases VR



↓↓ ↑↑

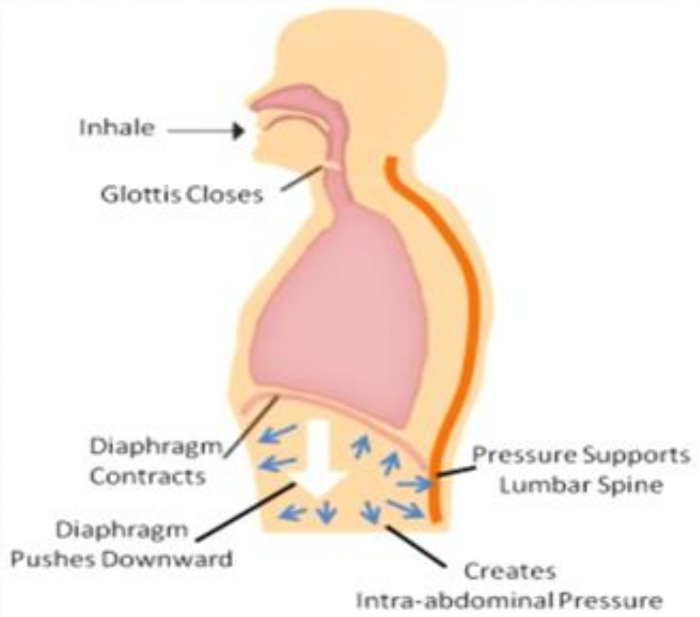
The effect of Valsalva Maneuver on VR

- <u>What is Valsalva maneuver?</u>

  It is forceful expiration against a closed glottis

- <u>What is the effect on VR</u>

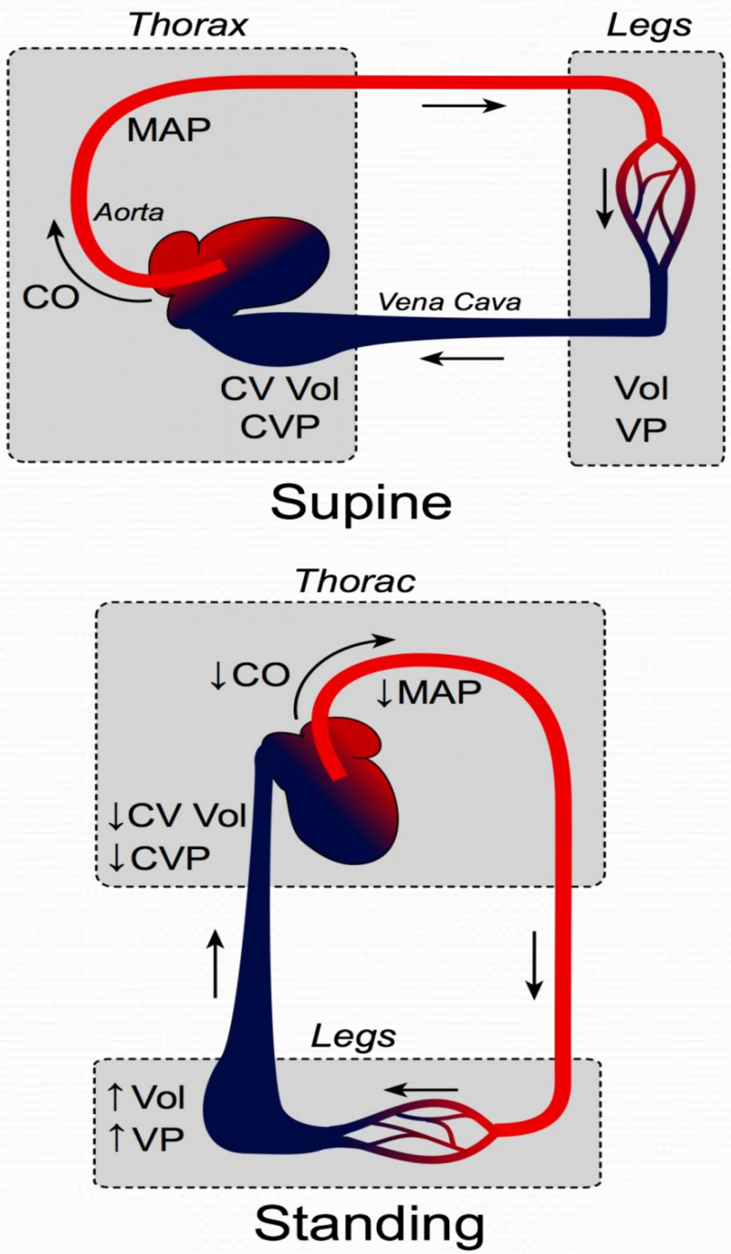
  Intrapleural pressure become positive which is transmitted to the large veins in the chest → ↓ venous return.



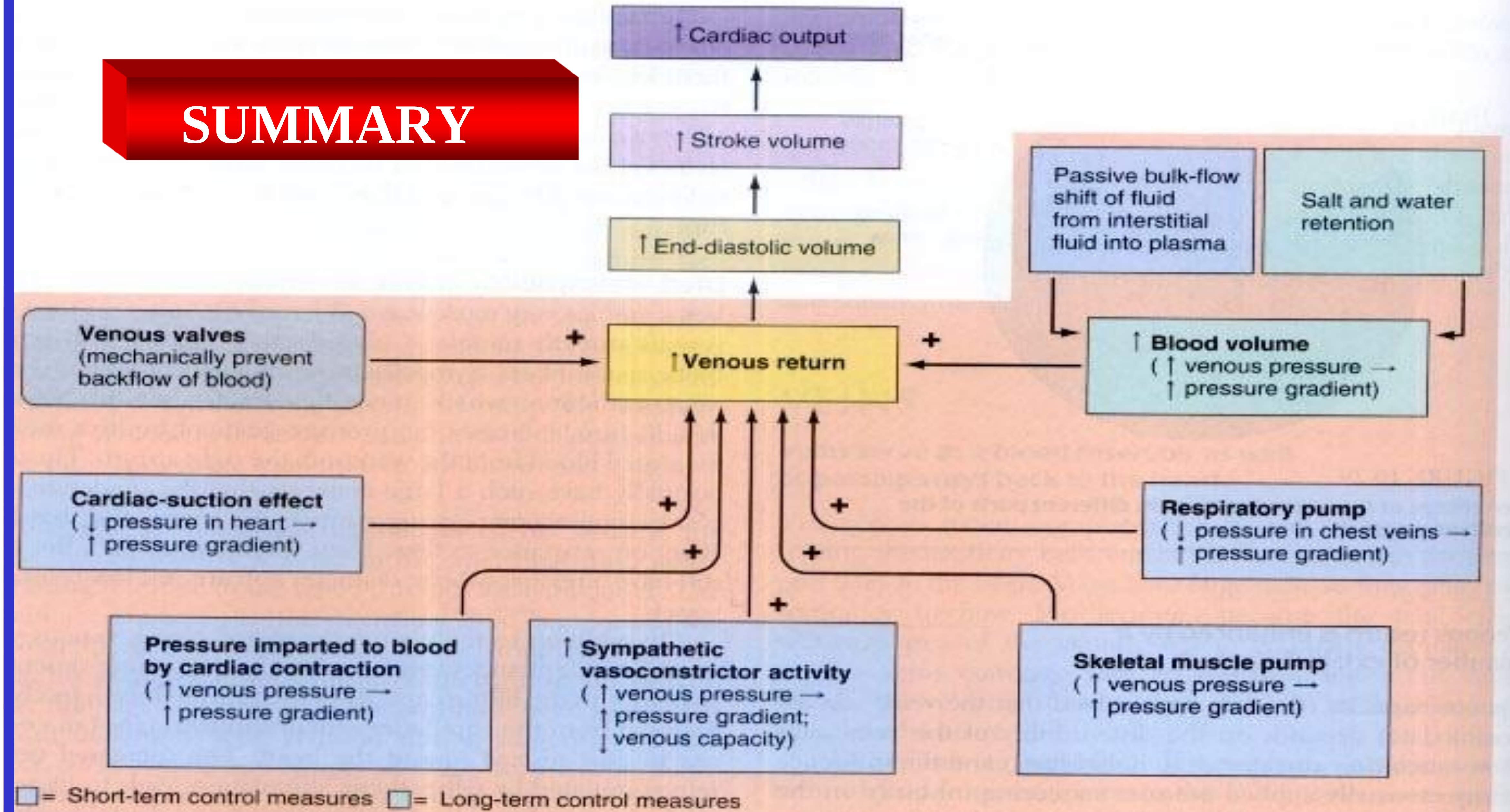
Determinants of Venous Return (Cont.)

9. Effect of gravity

- In standing, venous volume and pressure ↑ in the feet and lower limbs
- This shift in blood volume →↓ thoracic venous blood volume and therefore ↓ CVP →↓ right ventricular filling pressure (preload) →↓ SV by the Starling mechanism.
- Left ventricular SV ↓ because of reduced pulmonary VR (left ventricular preload).
- This causes CO and mean arterial pressure (MAP) to fall.
- If MAP falls significantly upon standing, this is termed orthostatic or postural hypotension.
- This fall in MAP can reduce cerebral blood flow to the point where a person might experience syncope (fainting)



SUMMARY


↑ Cardiac output
↑ Stroke volume
↑ End-diastolic volume
↑ Venous return
Venous valves (mechanically prevent backflow of blood)
Passive bulk-flow shift of fluid from interstitial fluid into plasma
Salt and water retention
↑ Blood volume (↑ venous pressure → ↑ pressure gradient)
Cardiac-suction effect (↓ pressure in heart → ↑ pressure gradient)
Respiratory pump (↓ pressure in chest veins → ↑ pressure gradient)
Pressure imparted to blood by cardiac contraction (↑ venous pressure → ↑ pressure gradient)
↑ Sympathetic vasoconstrictor activity (↑ venous pressure → ↑ pressure gradient; ↓ venous capacity)
Skeletal muscle pump (↑ venous pressure → ↑ pressure gradient)
+
= Short-term control measures
= Long-term control measures

سبحانك اللهم وبحمدك أشهد أن لا أله إلا أنت، استغفرك وأتوب اليك