# Venous return

Physiology Team 439

MED439
KING SAUD UNIVERSITY

Black: in male / female slides

Red : important

Pink: in female slides only

Blue: in male slides only

Green: notes

Gray: extra information

Editing File

# Objectives

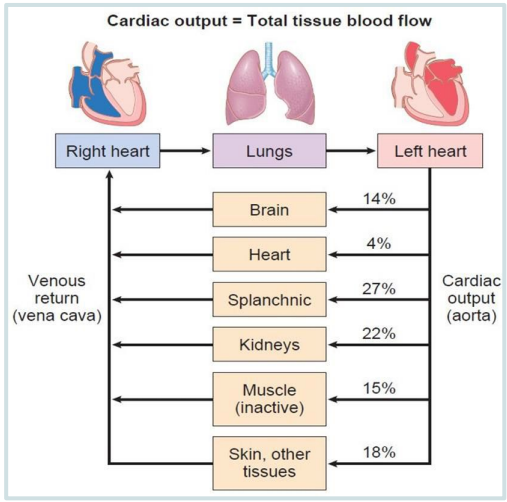
- Discuss functions of the veins as blood reservoirs.
- Describe measurement of central venous pressure (CVP) and state its physiological and clinical significance.
- State determinants of venous return and explain how they influence venous return.
- Define mean systemic filling pressure, give its normal value and describe the factors which affect it.
- Explain the effect of gravity on venous pressure and explain pathophysiology of varicose veins.
- Describe vascular and cardiac function curves under physiological and pathophysiological conditions.

# Cardiac Output = Total Blood Flow

**Why does the normal venous return must equal cardiac output?**

From the figure : cardiovascular system is essentially a closed loop.Otherwise, blood would accumulate in either the systemic or pulmonary
circulations.

From Guyton: The venous return and the cardiac output must equal each other except for a few heartbeats at a time when blood is temporarily stored in or removed from the heart and lung.

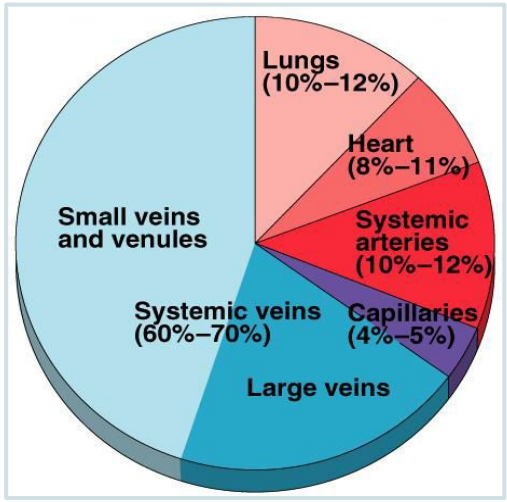



# What is about the veins?

- Veins hold most of blood in body (70 %),
- They are called **capacitance vessels.**
- Veins Have **thin walls** & **stretch easily** to accommodate more blood without increased pressure (= higher compliance). . If you remember compliance v/p
- Veins have 0 -10 mm Hg Pressure

Veins: have huge capacity and low pressure
Arteries: have small capacity and high pressure

## Blood distribution




NOTE:
maximum blood distribution is found in systemic veins, so they act as capacitance vessels which are responsible for **accommodating blood**.

# Veins are blood reservoirs

Because they have high capacity they are blood reservoirs

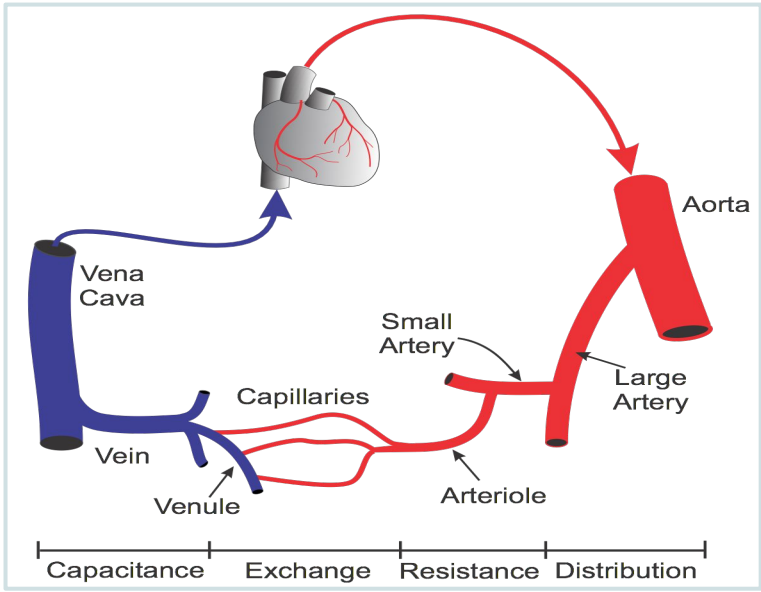
- When the body is **at rest** and many of the capillaries are closed, the **capacity** of the **venous reservoir is increased** as extra blood bypasses the capillaries and enters the veins.
- When this extra volume of blood stretches the veins (without significant change in pressure due to venodilation), the blood moves forward through the veins more **slowly** because the total **cross sectional area of the veins has increased** as a result of the stretching. Therefore, blood spends more time in the veins.
- When the stored blood is needed, such as during exercise, extrinsic factors reduce the capacity (during contraction of the muscles ,it will squeeze the viens)of the venous reservoir and drive the extra blood from the veins to the heart so that it can be pumped to the tissues.

**what changes will occur during exercise?** arterioles will dilate, veins undergo constriction, this will lead to supplying more blood to muscular tissue when needed.

# Systemic circulation

**The points that are needed to know from the figure are:**

- **Arterioles** (resistance vessels) offer maximum resistance
- **Capillaries**(exchange vessels) are responsible for gas exchange between blood and tissues but offer minimum resistance
- **veins** (capacitance vessels) are responsible for accommodating blood when needed during blood loss.



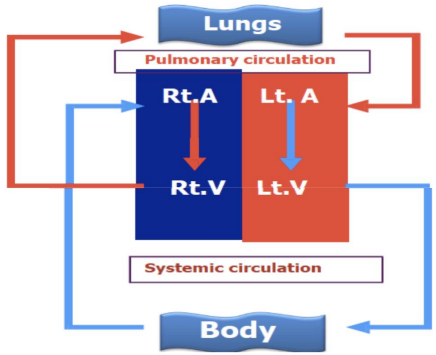
# venous return

- **Normally venous return must equal cardiac output (CO) when averaged over time because the cardiovascular system is essentially a closed loop. Otherwise, blood would accumulate in either the systemic or pulmonary circulations.**

-Venous return is determined by the **difference** in pressure between the venous pressure nearest to the tissues (mean systemic filling pressure) "Psf" other name is (mean circulatory pressure "MCP" ) and the (central venous pressure nearest to the heart "CVP" ).

- **VR= CO** when averaged over time because the CVS is essentially a closed loop. Otherwise, blood would accumulate in either the systemic or pulmonary circulations. How the blood accumulate ? It explained more in JVP lecture .

mean systemic filling pressure(Psf) or mean circulatory pressure[MCP] is the sum of all pressures between the maximum and minimum.




**The figure above indicates that: the maximum pressure during rapid ejection is in left ventricle and the the minimum pressure during the end of diastole is in right ventricle.**

# structure of veins

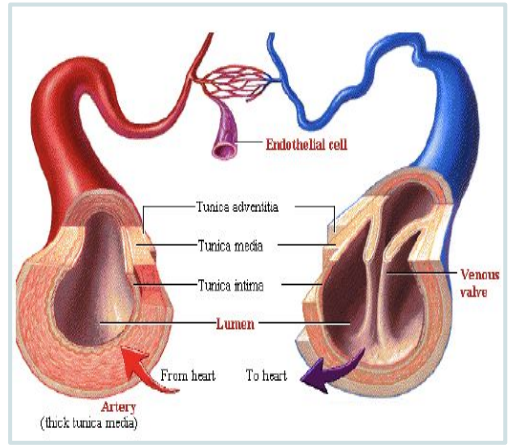
- All 3 layers of veins are present;

  1-tunica adventitia, 2-tunica media. 3- tunica intima.

layers in veins are **thinner** than in arteries of corresponding size (external diameter).

- Veins have paired semilunar, bicuspid valves to restrict backflow in lower extremities.same valve in mitral
- Not all veins have valves so the valves are located in the deep veins of the leg.

  (gravityغالبا اللي تكون تحت فيها صمامات عشان تأثير ال )

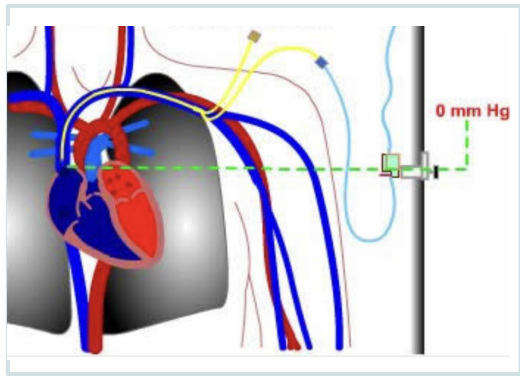



# Varicose veins الدوالي

- Varicose veins are caused by **weak or damaged valves** of the veins.
- In varicose veins, blood won't flow back properly to the heart, so black pools occur because valves will fail causing venous walls to expand.

# 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}.

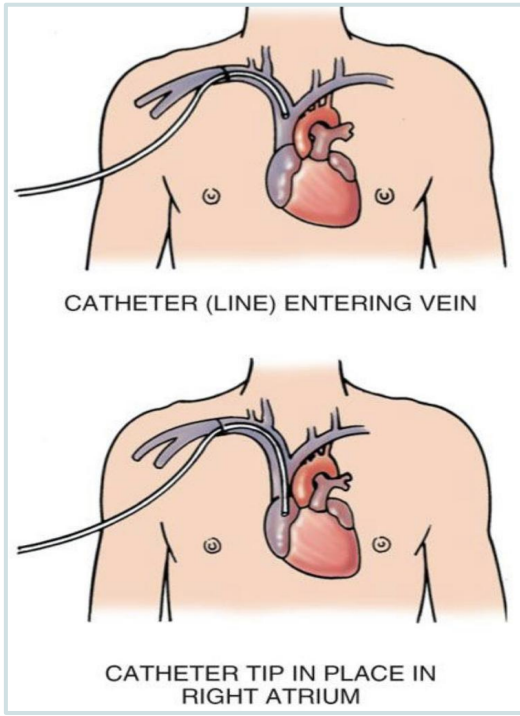



- CVP is measured with a catheter inserted in SVC(superior vena cava) .
- The normal range of the **CVP = 0 - 4** mmHg.
- It is the force responsible for cardiac filling

(لان اذا كان 0 مثلا فالفرق راح يكون كبير وبيرجع الدم للقلب)

- CVP is used clinically to assess

**1- hypovolemia** 2- **during IV transfusion to avoid volume overloading (hypervolemia)**




- CVP is **raised** in **right-sided heart failure**

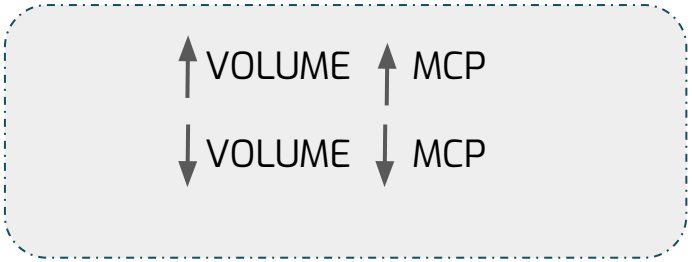
**Right - sided heart failure : failure of the heart to pump the blood as a result there will be accumulation of the blood in the atrium so the CVP will increase**

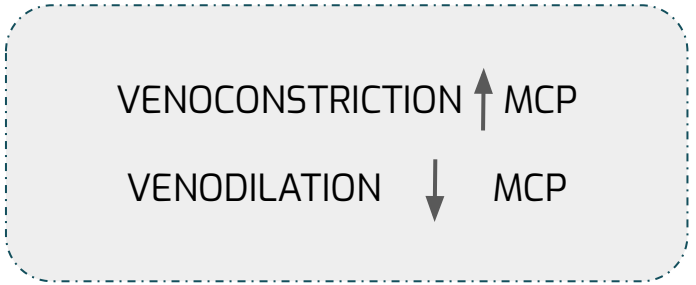
# Mean Systemic Filling Pressure (MSFP)
# Mean Circulatory Pressure (MCP)

**MCP** and **MSFP** is the pressure nearest to the tissues and is about **7 mm Hg.**
The value for right atrial pressure at which venous return is zero is called the mean systemic filling pressure. This mean that if the **CVP = MCP** the VR will equal to **ZERO**

**MCV IS AFFECTED BY:**

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




NOTE THAT : vasoconstriction = decrease in venous capacity and vice versa.

# The Venous Return Curve
# the vascular function curve

The curve relates **VR To Rt**. "Right Atrial Pressure"
Mean systemic filling pressure is the point at which the vascular function curve intersects the X-axis
(i.e., where VR is zero and Rt. atrial pressure is at its highest value).عكسيه

**From guyton:**The curve is the normal venous return curve. This curve shows that when heart pumping capability becomes diminished and causes the right atrial pressure to rise, the backward force of the rising atrial pressure on the veins of the systemic circulation decreases venous return of blood to the heart. If all nervous circulatory reflexes are prevented from acting, venous return decreases to zero when the right atrial pressure rises to about +7 mm Hg. Such a slight rise in right atrial pressure causes a drastic decrease in venous return because any increase in back pressure causes blood to dam up in the systemic circulation instead of returning to the heart.

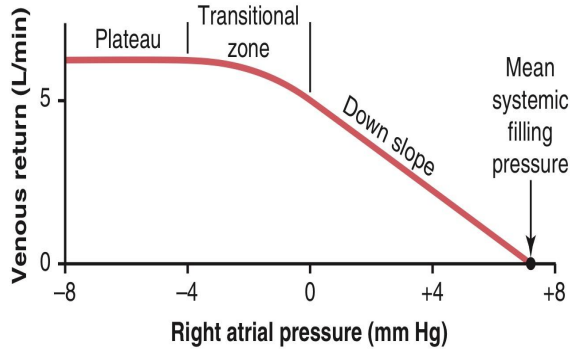



**Figure 20-10.** Normal *venous return curve*. The plateau is caused by *collapse* of the large veins entering the chest when the right atrial pressure falls below atmospheric pressure. Note also that venous return becomes zero when the right atrial pressure rises to equal the mean systemic filling pressure.

The blood flow from high to low pressure so RAP must become lesser to make the blood flow from systemic vein to RA

↑ **RAP** ↓ **VR** ↑ **Co**

Will be Discussed later on

**The cardiac output curve relates pumping of blood by the heart to right atrial pressure.**طرديه

Because increased RAP=increased FILLING in the ventricle and therefore increased CO

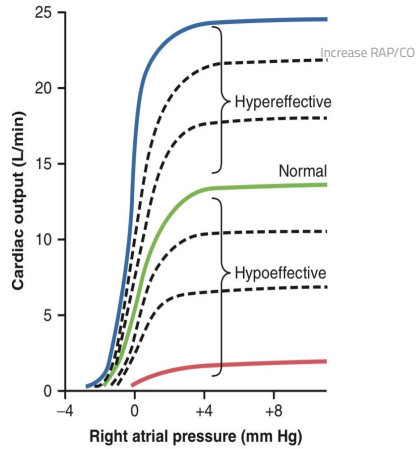
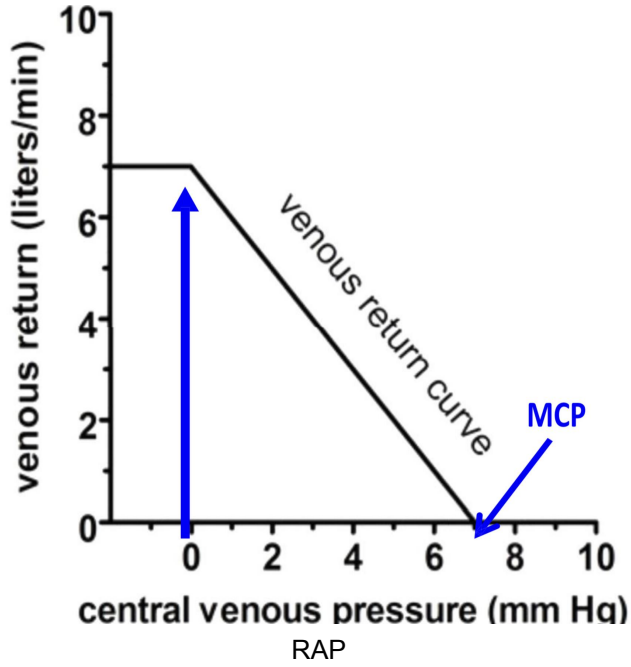



**Figure 20-5.** Cardiac output curves for the normal heart and for hypoeffective and hypereffective hearts. *(Modified from Guyton AC, Jones CE, Coleman TB: Circulatory Physiology: Cardiac Output and Its Regulation, 2nd ed. Philadelphia: WB Saunders, 1973.)*

# The Venous Return Curve
# the vascular function curve

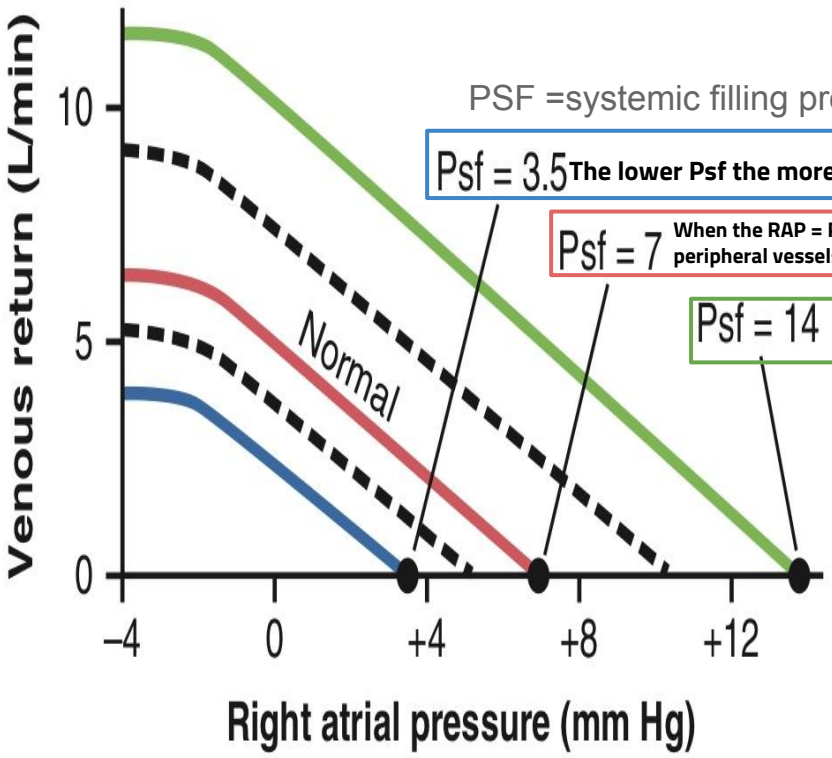
- There is an **inverse relationship** between **venous return** and **right atrial pressure (RAP).**
- Venous return back to the heart, like all blood flow, is driven by a pressure gradient. The **lower the pressure in the right atrium**, the **higher the pressure gradient** and the **greater the VR.**
- Thus as **RAP increases**, this **pressure gradient decreases** and **VR decreases.**
- **The knee (flat portion)** of the vascular function curve occurs at **negative values of RAP.** At such negative values, the veins collapse & impedes VR in spite of high pressure gradient.




**Important**

Boys doctor hinted that there might be questions regarding the figure above such as; what the points, arrows, or axis represent.

# Pressure Gradient For Venous Return:
# The Greater The Difference Between The Psf And The RAP, the greater becomes the VR




PSF =systemic filling pressure (veins pressure in tissue level )

Psf = 3.5 **The lower Psf the more the curve shifts downward and to the left.** Lesser VR Because less gradient

Psf = 7 **When the RAP = Psf, there is no longer any pressure difference The Greater The Difference Between The Psf And The RAP, between the peripheral vessels and the right atrium. Resulting in ?** The Greater Becomes The VR No venous return

Psf = 14 **Greater the Psf (14) (which also means the greater the "tightness" with which the circulatory system is filled with blood), the more the venous return curve shifts upward and to the right.**

Blood volume

Female slides ONLY

## Effect of altering Blood volume on VR

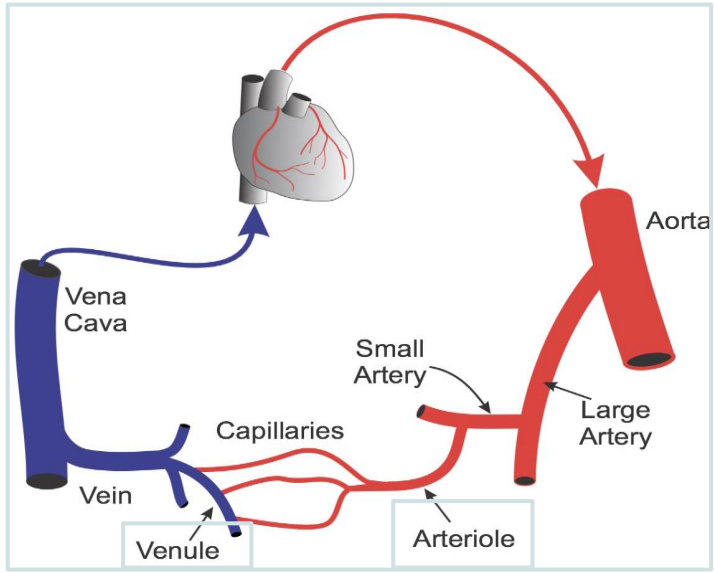
- If **blood volume increases, Psf increases(14)** and the vascular function curve and its intersection point with **the X-axis shift to the right**. The same effect is seen with venoconstriction. [Stressed volume]
- If **blood volume decreases, Psf decreases(3.5)**, and the vascular function curve and its intersection point with **the X-axis shift to that the left**. The same effect is seen with venodilation. [stressed volume]

Girls slides only

# Total pressure Resistant

- When the **TPR is decreased**, for a given RAP, venous return is increased. In other words, **decreased resistance** of the arterioles(decreased TPR) makes it easier for blood to flow from the arterial to the venous side of the circulation and back to the heart.عكسي

- When the **TPR is increased**, for a given RAP, venous return is decreased. In other words, **increased resistance** of the arterioles (increased TPR) makes it more difficult for blood to flow from the arterial to the venous side of the circulation and back to the heart.




**From Guyton:**
**Effect of Resistance to Venous Return on the Venous Return Curve.**
demonstrates the effect of different levels of resistance to venous return on the venous return curve, showing that a decrease in this resistance to one-half normal allows twice as much low of blood and, therefore, rotates the curve upward to twice as great a slope. Conversely, an increase in resistance to twice normal rotates the curve downward to one half as great a slope.

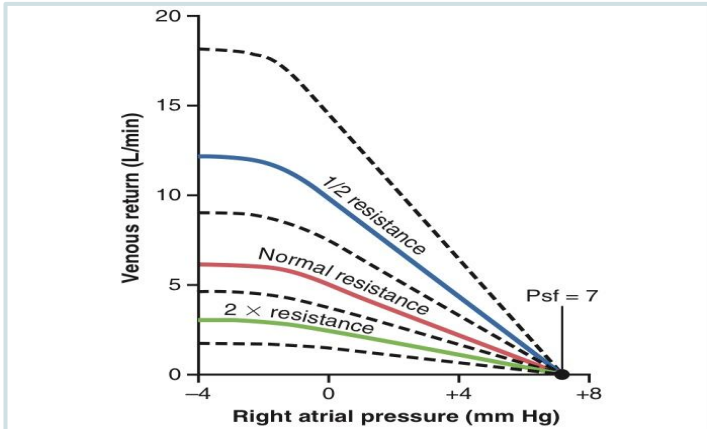



**Figure 20-13.** Venous return curves depicting the effect of altering the resistance to venous return. Psf, mean systemic filling pressure. *(Modified from Guyton AC, Jones CE, Coleman TB: Circulatory Physiology: Cardiac Output and Its Regulation, 2nd ed. Philadelphia: WB Saunders, 1973.)*

TPR : total pressure Resistance

# Determinants of venous return

VR

**1. Blood volume**

- At **constant venous capacity**, when the blood volume rise ↑, the MCP rise ↑, and VR rise ↑.
- At **constant venous capacity**, when the blood volume decrease ↓, the MCP decrease ↓, and VR decrease ↓.

**2. Venous capacity:** is the volume of the blood that the veins can accommodate.

- At a **constant blood volume**, when the venous capacity rise ↑, the MCP decrease↓,and the VR decrease↓
- At a **constant blood volume ,** when the venous capacity ↓, the VR ↑(↑MCP)

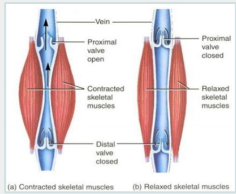
**3. sympathetic activity**

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

but the artery dilated,why? to more perfusion

**4. 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 during exercises




Skeletal muscle pump enhancing venous return

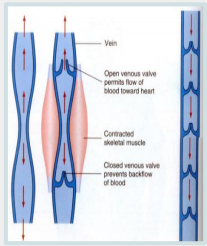
# Determinants of venous return

VR

**5. Venous valves:**These valves permit blood to move forward towards the heart but prevent it from moving back
toward the tissues. These 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**.

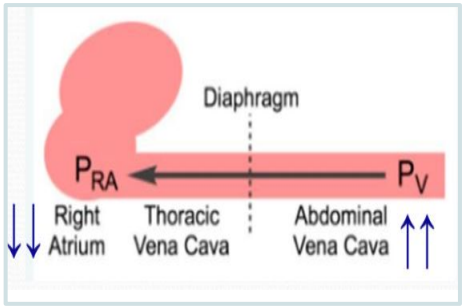
- Chronically raised pressure in the veins leads to pathological distention of the veins (**varicose veins**).
- Increased capillary filtration leads to swelling (edema) with trophic skin changes and ulceration. (**venous ulcers**).

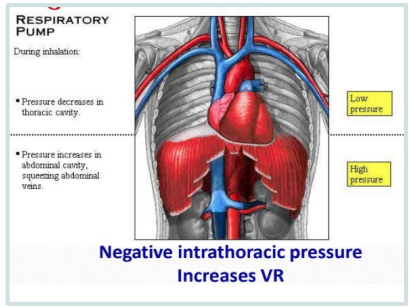



treatment: do not stand for along time

**6. Respiratory activity (respiratory pump,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 5 mmHg less than atmospheric pressure.( if you recall in Respa block pressure in the chest cavity = intraplureal pressure = -5mmHg )
- 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 venous return (this is known as the **respiratory pump**).




the cardiac suction effect also determines of venous return : decrease pressure in heart lead to rise pressure gradient witch rise VR

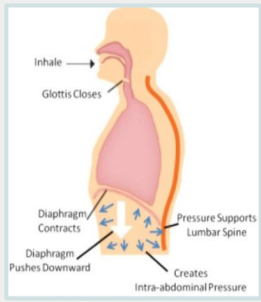
# Determinants of venous return

VR

## 7- The effect of Valsalva Maneuver on VR

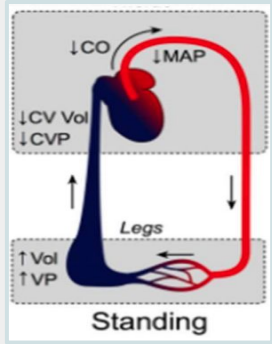
**What is Valsalva maneuver?**It is forceful expiration against a closed glottis.
**What is the effect on VR ?**Intrapleural pressure become positive which is transmitted to the large veins in the chest→ venous return ↓.

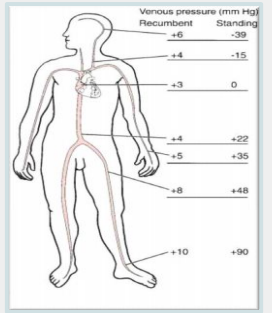
what is the effect of valsalva maneuver on venous return ?
venous return will decrease because intrapleural pressure become positive




## 7. Effect of gravity

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



# MCQs:

**1- The highest blood distribution is found in:**
A) Systemic arterioles
B) Systemic veins
C) Pulmonary vessels
D) Systemic arteries

**2- Which one of the following is not included in the structure of veins?**
A) Tunica adventitia
B) Venous valves
C) Hyaline cartilage
D) Lumen

**3- What type of blood vessels are known as resistance vessels?**
A) Veins
B) Capillaries
C) Venules
D) Arterioles

**4- what is the relationship between right atrial pressure and venous return.**
A) direct relationship
B) no relationship
C) inverse relationship
D) other relationship

**5-when TRP decreases what happened to VR?**
A) decrease
B) no change
C) increases
D)both B/C

**6-Mean Systemic Filling Pressure (MSFP) effected by:**
A) venous return
B) blood volume
C) venous capacity
D) both B/C

**7-Chronically raised pressure in the veins leads to pathological distention of the veins named as:**
A)venous ulcers
B)venous edema
c)varicose veins
D)Valsalva maneuver

**8-skeletal contraction activity:**
A) decrease venous capacity
B) raised sympathetic activity
C) decrease MCP
D) none of above

**9-the effect of Valsalva maneuver on VR:**
A) intrapleural pressure become negative and the VR arise
B) intrapleural pressure become negative and decrease
C) intrapleural pressure become positive and the VR arise
D) intrapleural pressure become positive and the VR decrease

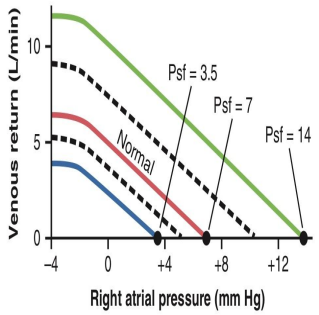
Answer Key: 1B - 2C - 3D -4C - 5C - 6D
7C - 8A -9D

# SAQs:

1- What are the significant changes in blood vessels that occur during exercise ?

2-describe the relationship between the Psf and venous return from the graph?

3-determines the changes in venous return when venous capacity constant and the blood volume change ?




**A1: arterioles will dilate, veins undergo constriction, this will lead to supplying more blood to muscular tissue when needed.**

**A2:-Greater the Psf (14) (which also means the greater the "tightness" with which the circulatory system is filled with blood), the more the venous return curve shifts upward and to the right.**
**-lower Psf the more the curve shifts downward and to the left "Lesser VR because less gradient "**

**A3:1-At constant venous capacity,when the blood volume rise ↑, the MCP rise ↑, and VR rise ↑.**
**2-At constant venous capacity, when the blood volume decrease ↓, the MCP decrease ↓, and VR decrease ↓.**

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