



Cardiovascular Block

Physiology Team 430

8th Lecture

Venous return and cardiac output

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■ Venous return :

It is the volume of blood which return to the right atrium per minute.

Factors controlling venous return :-

1- **Skeletal muscle pump**. (when the muscle contracts. It comprise the vein, so the blood will move in one direction, leading to increase venous return)

2- **Respiratory pump** (↑ in inspiration).

(when we inspire air , the intrapulmonary pressure become negative, this pressure will be transported to the near veins, so more blood will go to the right atrium , increasing the venous return)

3- **Blood volume** (in a case of hemorrhage , there will be decrease in the blood volume leading to decrease venous return)

4- **Pressure gradient** (pressure in small veins is higher than pressure in larger veins , so the blood is moving from small veins to large veins – the higher the difference – the higher venous return).

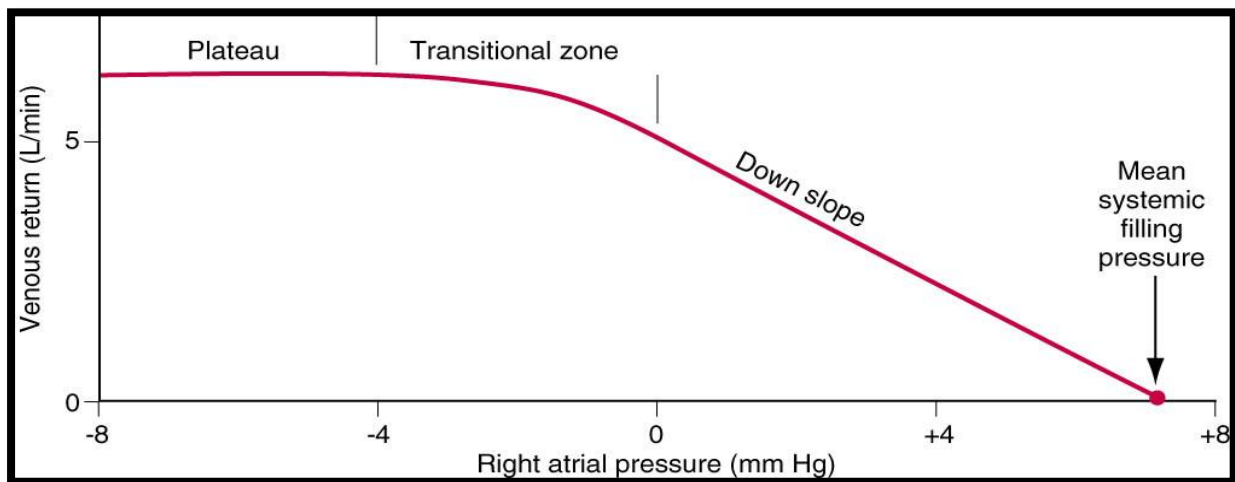
5- **Venous pressure**. (it's affected by sympathetic activity , when it increases the venous return increases)

6- **Gravity** (it's **inversely** related to venous return . when the person stands , the venous pressure will be decreased)

Why does veins called "**capacitance vessels** " ??

Because they have **Have thin walls & stretch easily to accommodate more blood without increased pressure (higher compliance)**

■ Venous return curve :



It shows the relationship between right atrial pressure & venous return

- The right atrial pressure is inversely related to the venous return
- The normal value of RAP "right atrial pressure " (-1 to +2)
- When the RAP decreases , the venous return increases , but when the RAP continues to decrease below -1 , there will be no further increase in the venous return due to collapse of the veins entering the chest " we can see a plateau in the curve "

Mean circulatory filling pressure :

The value for right atrial pressure at which venous return is **zero** is called **the mean systemic pressure**. **Mean systemic pressure** or mean circulatory pressure is the pressure that would be measured throughout the cardiovascular system if the heart were **stopped**.

- Effect of blood volume on mean circulatory filling pressure :-

When the blood volume ranges **from 0 to 4 L**, all of the blood will be in the unstressed volume (**the veins**), producing no pressure, and the mean systemic pressure will be **zero**. When blood volume is **greater than 4 L**, some of the blood will be in the stressed volume (**the arteries**) and produce pressure. For example, if the total blood volume is **5 L**, **4 L** is in the unstressed volume, producing no pressure, and **1 L** is in the stressed volume, producing a pressure of approximately **7 mm Hg**.

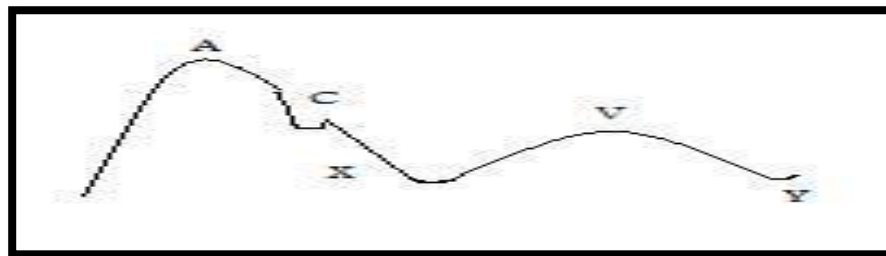
■ Jugular Venous Pressure (Pulse):

We measure it from the SVC , it reflects the pressure in the right atrium , because , there is no valve between them

Is the indirectly observed pressure over the venous system

It can be useful in the differentiation of different forms of **heart** and **lung disease**.

Classically three upward deflections and two downward deflections have been described.



The upward deflections are:

The "a" (atrial contraction),

The "c" (ventricular contraction and resulting bulging of tricuspid into the right atrium during isovolumic systole),

and The "v" (atrial venous filling),

The downward deflections of the wave are:

the "x" (the atrium relaxes and the tricuspid valve moves downward),

and the "y" descent (filling of ventricle after tricuspid opening).

Raised jugular venous pressure

Causes of raised JVP::

1- Increased right ventricular filling pressure e.g in heart failure , fluid overload." The pressure in the right ventricle will be higher than the right atrium , so the blood will accumulate in the atrium , raising JVP"

Remember that : blood moves from area of high blood pressure , into an area of low blood pressure

2- Obstruction of blood flow from the right atrium to the right ventricle e.g tricuspid stenosis.

3- Superior vena cava obstruction e.g retrosternal thyroid goitre.

4- Positive intrathoracic pressure e.g pleural effusion, pneumothorax.

The JVP usually drops on inspiration along with intrathoracic pressure.

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■ The cardiac output (c.o):

It is the volume of blood ejected from the right or left ventricle per minute = **5 L./min.** at **rest**.

$$\text{C.O.} = \text{Heart rate} \times \text{Stroke volume.}$$

Stroke volume is the volume of blood ejected from each ventricle per beat = **70** mls. / beat at rest

Heart rate at rest = **72** or **70** beats /min.

Notice that : in normal conditions the HR has the same value as the venous return "
5L/min "

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■ Factors affecting cardiac output :

Generally cardiac output is controlled by ANS "sympathetic & parasympathetic" which are tightly regulated by cardiac control centre of medulla .

In addition to that there are several factors controlling the cardiac output :

- **body metabolism** : there will be increase in the temperature—leading to vasodilatation – increasing the heart rate and then the C.O
- **exercise**: the same effect of body metabolism & activation of sympathetic N.S
- **hyperthyroidism** : increase the HR—leading to increase in the C.O
- **Age** : aging **decreases** the C.O
- **pregnancy** : increase blood volume – increase HR—increase in the C.O

■ Cardiac index:

It relates the cardiac output (CO) to body surface area (BSA)

cardiac output /m² of body surface area

the unit is : (L/min/m²).

Better cardiac index—better contraction of the heart

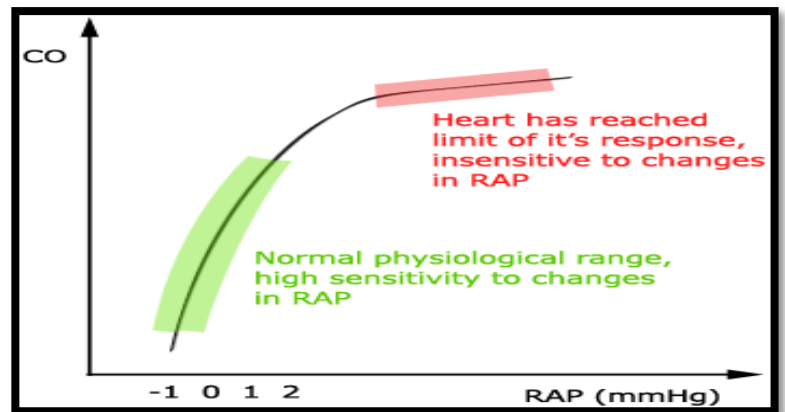
New born babies have low cardiac index, but when they reach 10 years old , they have the highest cardiac index , then it starts decreasing

■ Cardiac function curve :

Graph showing the relationship between the right atrial pressure and the cardiac output .

Normally : when the RAP increases , the C.O will increases too, but there are limits for this increasing . when the RAP increase above +2 , there will be no further increase in the C.O

The normal value of C.O = 5 L/min , but it can reaches 13 L/min , during exercises or cardiac hypertrophy



■ Measurement Of C.O.

The Direct Fick s Method:- " this method is used to measure C.O in the Lab" :

It states that, the amount or volume of any substance taken up by an organ or by the whole body is equal to:

(The arterial level of the substance "usually O₂" – the venous level) X blood flow

$$\text{Blood flow} = \frac{\text{Amount}}{\text{Arterial level} - \text{Venous level}}$$

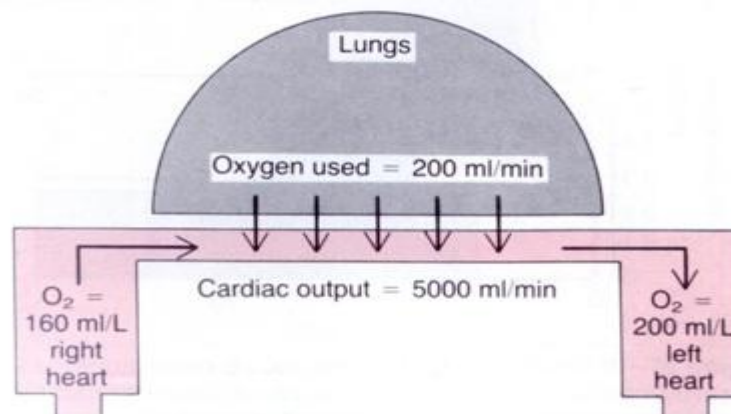


Figure 20-18. The Fick principle for determining cardiac output.