



Cardiovascular Block

Physiology Team 430

## 10<sup>th</sup> Lecture

Regulation of stroke volume1:  
preload effects on the heart

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## \* Cardiac contractility and stroke volume

Systolic function of the heart is controlled by:

1. Contractile state of the myocardium.
2. Preload of the ventricle.
3. Afterload applied to the ventricle.
4. Heart Rate.

## \* How to measure the cardiac output (CO) ?

→ CO = stroke volume multiplied by heart rate

→ Fick Principle :

$$CO = \frac{V_{O_2} \text{ (whole body oxygen consumption)}}{(O_{2art} - O_{2ven}) \text{ the mixed venous and arterial oxygen contents}}$$

If  $O_{2art}$  and  $O_{2ven}$  contents = 0.2 ml and 0.15 ml  $O_2$ /ml blood,  
 $V_{O_2}$  = 250 ml  $O_2$ /minute, then CO = 5000 ml/min, or 5 L/min. Ventricular stroke volume would simply be the cardiac output divided by the heart rate.

## \* Heart Failure :

### ❖ What is heart failure ?

Heart failure is a term used to describe the condition when the heart becomes less efficient at pumping blood and is therefore unable to meet the demands of the body.

The heart is not pumping properly. Usually, the heart has been weakened by an underlying condition :

- Blocked arteries
- Heart attack (blockage of coronary arteries)

- High blood pressure (heart contract against high pressure → Fatigue →hypertrophy→ need more blood supply → heart failure.)
- Infections
- Heart valve abnormalities

### ❖ Pathophysiology of heart failure :

Heart failure can be caused by factors originating from within the heart (i.e., intrinsic disease or pathology) or from external factors that place excessive demands upon the heart. **Intrinsic disease** includes conditions such as dilated cardiomyopathy and hypertrophic cardiomyopathy. **External factors** that can lead to heart failure include long-term, uncontrolled hypertension, increased **stroke volume** (volume load; arterial-venous shunts), hormonal disorders such as hyperthyroidism, and pregnancy.

### ❖ Causes :

- Heart attack :

An artery supplying blood to the heart becomes blocked. Therefore loss of oxygen and nutrients will damage the heart's muscle tissue and causing it to die (**myocardial infarction**). But the remaining healthy heart muscle must pump harder to keep up.

- High blood pressure (very common cause):

Uncontrolled high blood pressure doubles a person's risk of developing heart failure (in left ventricle). Heart must pump harder to keep blood circulating. Over time, chamber first thickens, and then gets larger and weaker.

- Coronary artery disease:

It is caused of the deposition of fat and cholesterol in the arteries of the heart, therefore less oxygen and blood supply will reach the heart's muscle and This causes the heart to work harder and occasionally damages the heart Muscle.

- **Valve disease**

- Idiopathic cardiomyopathy (heart muscle diseases)
- Viral or bacterial cardiomyopathy
- Heart inflammation : Myocarditis , pericarditis
- Arrhythmias :  
If the heart beats too fast, too slow or irregular it may not be able to pump enough blood to the body.
- Chronic hypertension
- Thyroid disease ( hyperthyroidism ) :  
Body metabolize is increased and overworks the heart.( ↑ body temperature → ↑ heart rate )
- Septic shock
- Severe Aneamia :  
The Heart will beat faster and might become exhausted with the effort due to the reduced number of red blood cells ( not enough red blood cells to carry oxygen )
- Diabetes
- Severe lung diseases
- Pregnancy : hyperdynamic circulation therefore the heart will work harder .

### ❖ Signs and symptoms of heart failure :

- Tiredness, fatigue & Difficulty with everyday activities.  
Heart can't pump enough blood to meet needs of bodies tissues, So Body diverts blood away from less vital organs (muscles in limbs) and sends it to the heart and brain ( this is why you feel pain or fatigue even if you exert any minimum force) .

### ❖ Development of heart failure :

The heart tries to compensate for the loss in pumping function by:

- 1- Developing more muscle mass.
- 2- Pumping faster.
- 3- Enlarging .

- **Acute Heart Failure** :

Acute heart failure develops **rapidly** and can be immediately life threatening because the heart does not have time to undergo compensatory adaptations.

Duration: **hours/ days**

Causes: cardiopulmonary by-pass surgery, acute infection (sepsis), acute myocardial infarction, severe arrhythmias

Management: pharmacological or surgical interventions.

- **Chronic Heart Failure** :

Chronic heart failure is a long-term condition that is associated with the heart undergoing adaptive responses ( such as dilation and hypertrophy) to a precipitating cause. **These adaptive responses, however can have a harmful effect ( deleterious ) .**

Duration : **months / years**

Causes : most common cause is heart attack .

❖ **Types of heart failure :**

- ➔ Heart failure can involve the left or right side of the heart or both.
- ➔ Usually the left side is affected first.
- ➔ Heart failure occurs when either side of the heart cannot keep up with the flow of blood.
- ➔ **Systolic and /or diastolic function of the heart is impaired as a result, CO is low and unable to meet the metabolic demands of the body**

## 1 - Left heart failure :

LHF is Failure of the [left side of the heart](#) (left ventricle) .

Oxygenated blood from the lungs is pumped by the left side of the heart to the rest of the body. Failure of the left side of the heart results in insufficient delivery of oxygenated blood to the body.



<b>Systolic failure:-</b>	<b>Diastolic failure:-</b>
The heart loses its ability to contract or pump blood into the circulation. (due to weakened ventricular muscle)	The heart loses its ability to relax because it becomes stiff. (EDV becomes very small because the heart can't expand and accommodate large amount of blood) .Heart cannot fill properly between each beat.

### → [Signs and symptoms :](#)

(are due to pulmonary congestion and low CO)

- **Tachypnea** (increased *rate* of breathing) and increased *work* of breathing (non-specific signs of respiratory distress).
- **Dyspnea** (Shortness of Breath )due to → Blood “backs up” in the pulmonary veins because the left ventricle can't pump blood properly to the systemic circulation → fluid leaks into the lungs → **pulmonary edema**.
- Difficulty in breathing when lying flat & Waking up with short of breath.

- **Rales or crackles**, heard initially in the lung bases, and when severe, throughout the lung fields suggest the development of pulmonary edema (fluid in the alveoli) → blood may “back up” in the lungs causing fluid to leak into the lungs (**pulmonary edema**).
- **Edema**
- **Cyanosis** which suggests severe hypoxemia, is a late sign of extremely severe pulmonary edema.
- a laterally **displaced apex beat** (which occurs if the heart is enlarged).
- **Heart murmurs** may be heard as a marker of increased blood flow, or increased intra-cardiac pressure. Heart murmurs may indicate the presence of valvular heart disease, either as a cause (e.g. aortic stenosis) or as a result (e.g., mitral regurgitation) of the heart failure (due to cardiac remodeling).

## 2- right heart failure :

- Usually occurs as a result of left heart failure
- Occasionally isolated right heart failure can occur due to lung disease or blood clots to the lung (pulmonary embolism).
- Leads to generalized edema → e.g. ankle edema and hepatomegaly.

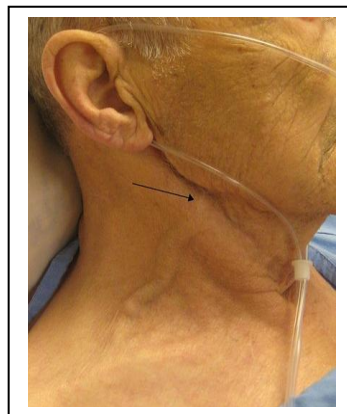


### → Signs and symptoms :

- **Edema** due to Blood returning to the heart from the veins “backs up” causing fluid to build up in tissues .
- Swelling in feet, ankles, legs or abdomen
- Weight gain
- **Ascites** (an abnormal accumulation of fluid in the abdomen)
- **Hepatomegaly** (enlargement of the liver )



- **Elevated Jugular venous pressure** .JVP is frequently assessed as a marker of fluid status, which can be marked by the hepatojugular reflux.  
 ↑ right ventricular pressure → a parasternal heave may be present, signifying the compensatory increase in contraction strength.



→ Right heart failure → ↑ Right atrial pressure → ANP (we will talk about it later) → which will lead to :-

- 1- ↑ heart rate ( to increase the cardiac output).
- 2- ↓ Anti diuretic hormone (ADH), Aldosterone, and renin → ↑ excretion of salt and water in urine.

Signs/symptoms	Left-sided heart failure	Right-sided heart failure
Pitting edema (legs, hands)	Mild to moderate	Moderate to severe
Fluid retention	Pulmonary edema(fluid in lungs) and pleural effusion(fluid around lungs)	Abdomen(ascites)
Organ enlargement	heart	Liver. Mild jaundice may be present
Neck veins	Mild to moderate raised jugular venous pressure	Dyspnea present but not as prominent
Shortness of breath	Prominent dyspnea .paroxymal nocturnal dyspnea	Dyspnea present but not as prominent
gastrointestinal	Present but not as prominent	Loss of appetite. Bloating.Constipation. symptoms are significantly more prominent than LVF



## ⌘ ANP ( atrial Natriuretic Peptide ) :

### What is ANP ?

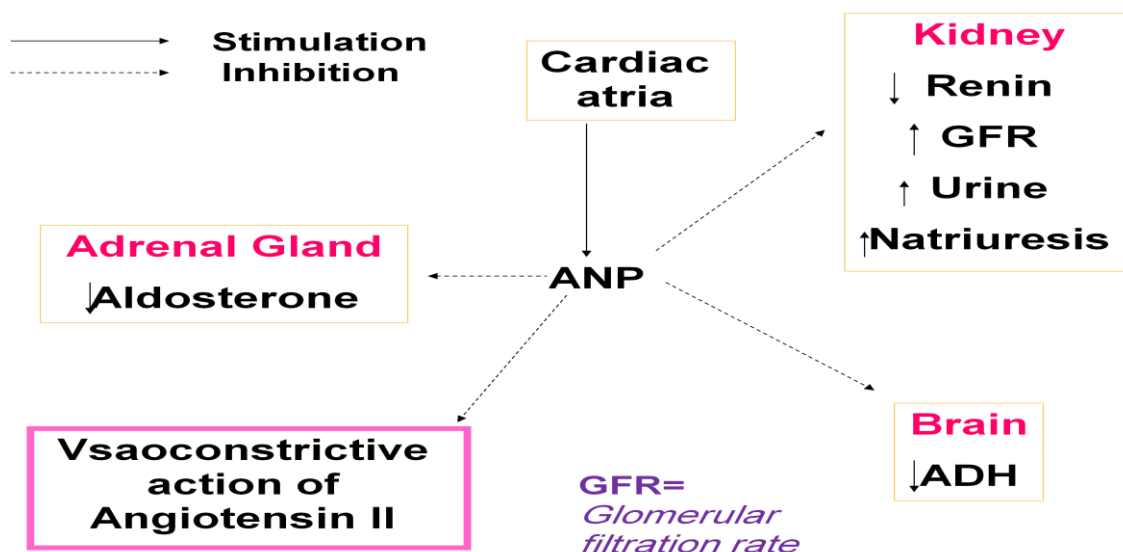
ANP Is a hormone synthesized in the atrium and is released into the circulation in response to atrial dilation or increased intravascular fluid volume.

### Whats its effect ?

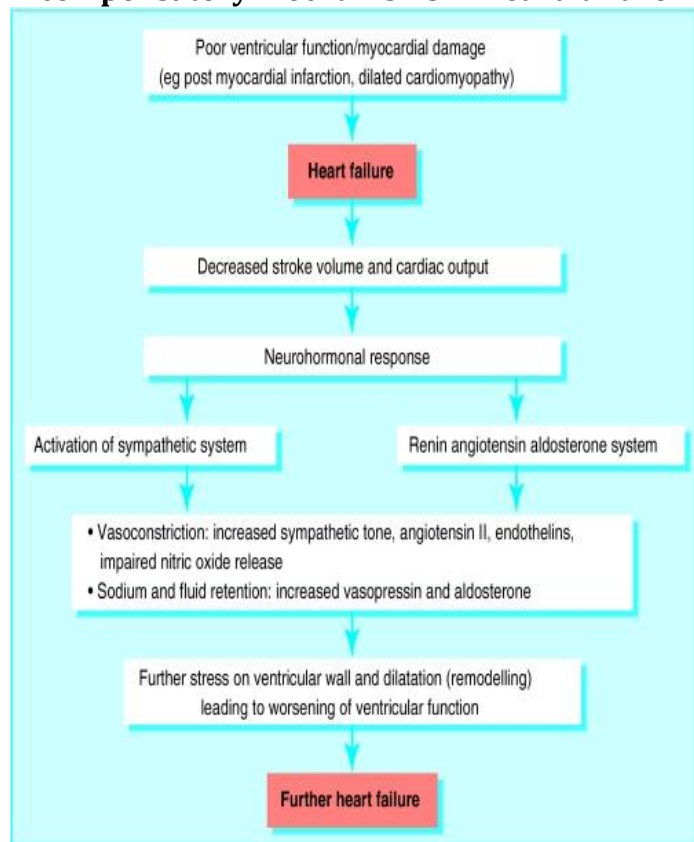
- It causes natriuresis (Excretion of excessive amounts of sodium in the urine which causes loss of sodium) ,
- Diuresis (excretion of the urine which causes loss of water ) ,
- renal vasodilatation;
- reduces circulating concentrations of renin, aldosterone, and antidiuretic hormone; and thereby normalizes circulating blood pressure and volume.

ANP Inhibits the release of renin, aldosterone and vasopressin (ADH)  
 Causes relaxation of blood vessels ( to decrease arterial blood pressure)  
 (aldosterone → reabsorption of Na, vasopressin (Antidiuretic Hormone)  
 → reabsorption of water .)

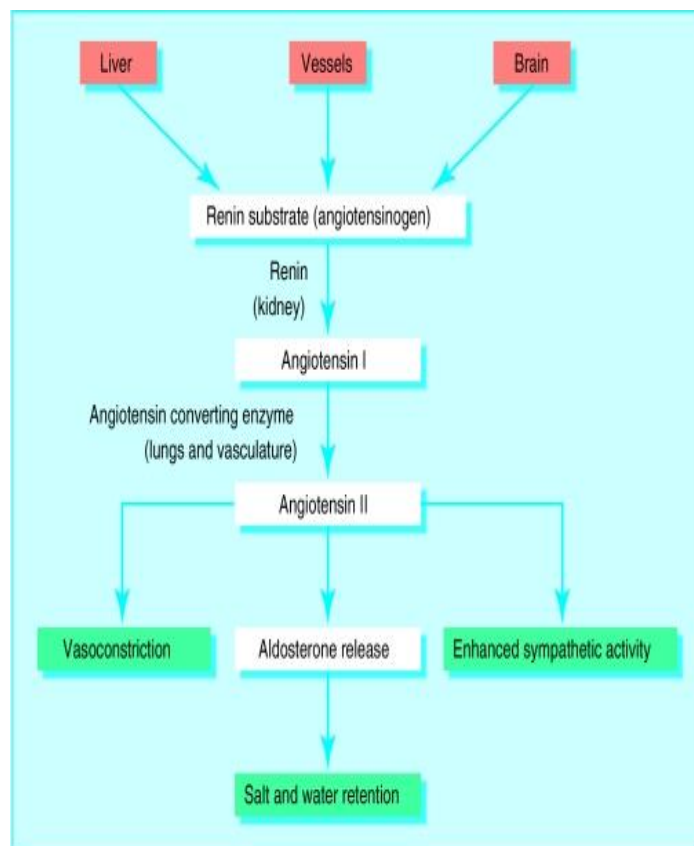
The body is trying to get rid of the excess water to reduce the damage caused by the heart failure .



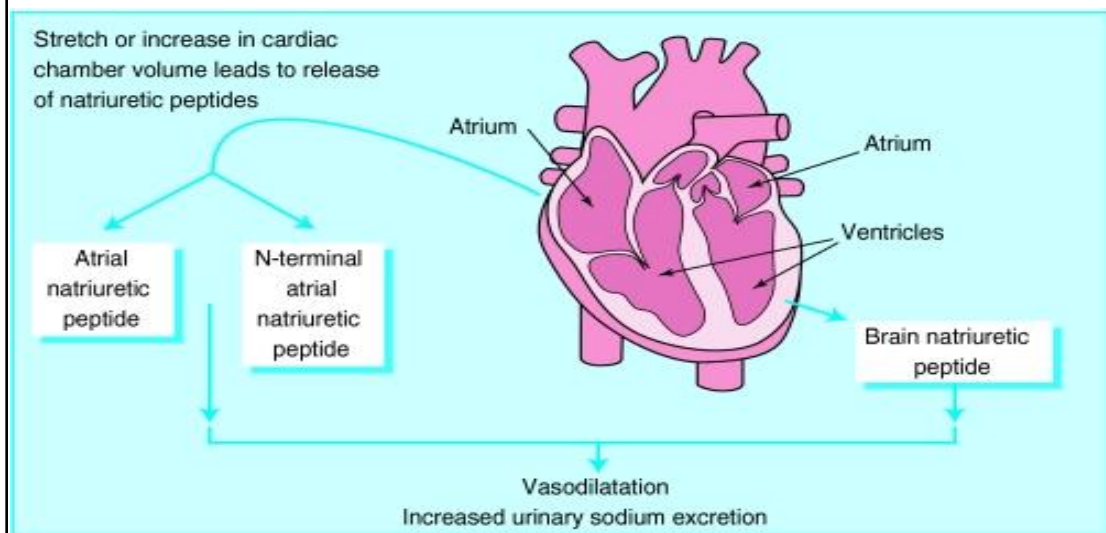
### Neurohormonal mechanisms and compensatory mechanisms in heart failure



### Renin-angiotensin-aldosterone system in HF



### ANP (atrial Natriuretic Peptide)



Good Luck 😊