10

CONTRACTILITY, STROKE VOLUME AND HEART FAILURE

MED 433 Teams
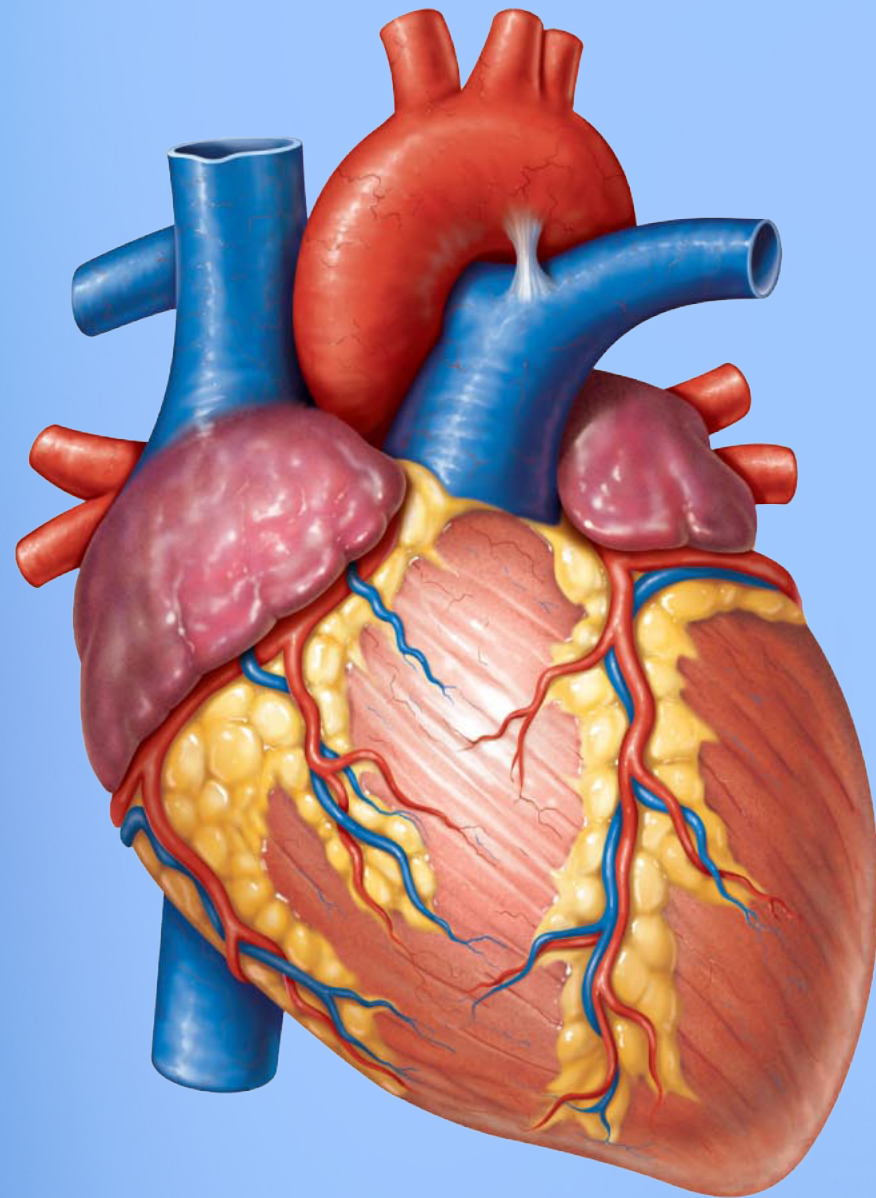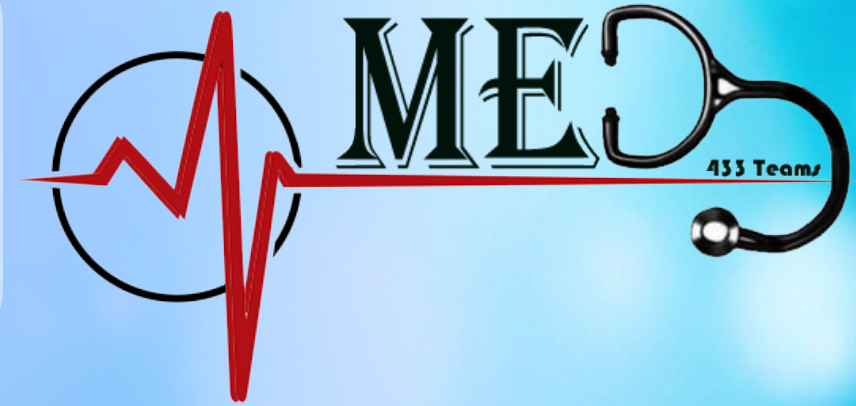
Cardiovascular

Block

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OBJECTIVES
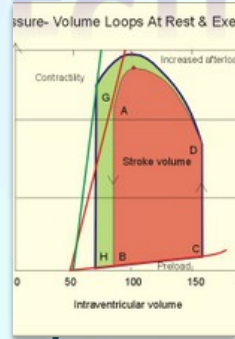
Explain how cardiac contractility affect stroke volume.

Calculate CO using Fick's principle equation.
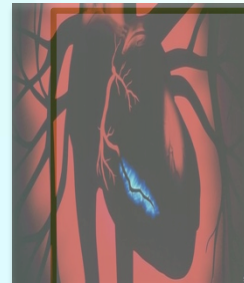
Explain pathophysiology of heart failure and differentiate between left and right failure.

Explain how the pathophysiology associated with heart failure results in typical signs and symptoms.

MIND MAP:

RHF
LHF
Acute HF
Chronic HF
Types of HF
Causes of HF
neurohormonal mechanisms & compensatory mechanism in HF

HEART FAILURE

Treatment
- reduction of cardiac out load
- Control retention of salt & water
- Enhance myocardial contractility

definition

Factors of HF
- Intrinsic factors
- Extrinsic factors

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1–sympathetic stimulation
2–Changes in **heart rate and rhythm** → Effect contractility of the myocardium → myocardium exerts a major influence on **SV.** → positive inotropic effect

MEASURING CARDIAC OUTPUT

measuring O2 consumption per minute

+

Arterio–venous oxygen difference.

→ 1– using Fick's principle equation

$$CO = \frac{VO_2}{C_a - C_v}$$

VO_2 =oxygen consumption in ml
CO = Cardiac Output,
C_a = Oxygen concentration of arterial blood.
C_v = Oxygen concentration of mixed venous blood.

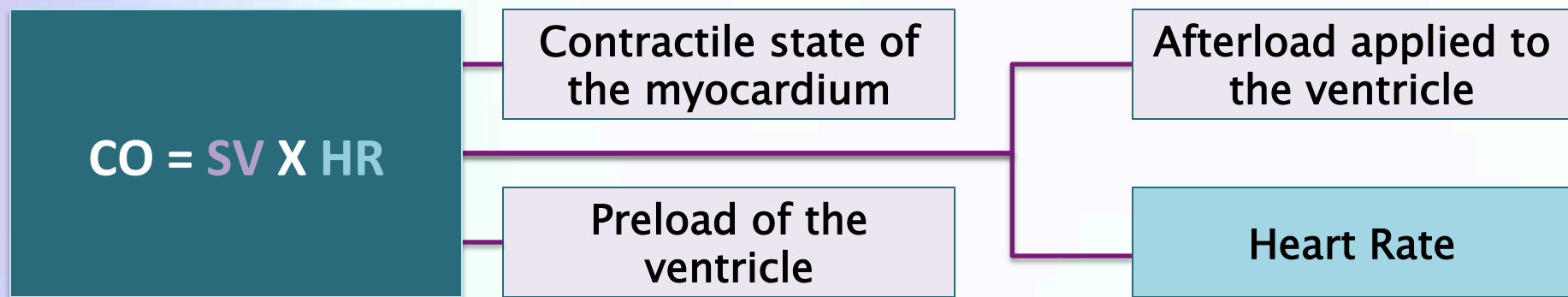**2- Echocardiographic** techniques

3- Ejection fraction=

$$EF = \frac{SV}{EDV} \times 100$$

4-Radionuclide imaging techniques

To estimate real-time changes in ventricular dimensions → SV
CO = SV X HR

SYSTOLIC FUNCTION OF THE HEART IS GOVERNED BY:

CO = SV X HR

- Contractile state of the myocardium
- Preload of the ventricle
- Afterload applied to the ventricle
- Heart Rate

SECOND: HEART FAILURE (HF)

What is Heart Failure?

It is a pathological process in which systolic and /or diastolic function of the heart is impaired

CO is low and unable to meet the metabolic demands of the body

factors of HF

Intrinsic factors:

1-Dilated cardiomyopathy .
2-Hypertrophic cardiomyopathy.
3-Myocardial infarction..

External factors:

1- Pressure load (long-term, uncontrolled hypertension).
2- increased **stroke volume by:**
A- volume load : arterial-venous shunt
B- hormonal disorders such as hyperthyroidism, and pregnancy

Causes of HF

Myocardial infarction
Coronary artery disease
Valve disease
Idiopathic cardiomyopathy
Viral or bacterial cardiomyopathy
Myocarditis
Pericarditis
Arrhythmias
Chronic hypertension
Thyroid disease
Septic shock
Aneamia
Arterio–venous shunt.

Types (1)

1- Acute HF.
2- Chronic HF.

1-Left-sided failure.
2- Right-sided failure.
3- Biventricular HF

1- Systolic failure.
2- Diastolic failure.

1- High output HF.
2- Low output HF.

1- forward failure.
2- Backward failure.

Treatment

control of congestive heart failure symptoms, can be divided into three categories:

reduction of cardiac workload, including both preload and afterload

control of excessive retention of salt and water

enhancement of myocardial contractility

Note

(1) The types that are written with grey are just for knowledge and will not be discussed ☺

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SECOND (A): ACUTE HF & CHRONIC HF

	Acute HF	Chronic HF
How fast it develops?	**Rapidly:** hours or days	**Long-term condition:** months or years.
Does it undergo adaptive responses[1]? (1) Example of adaptive responses : 1. Dilation, 2. Hypertrophy	life threatening <u>because</u> the heart **DOES NOT HAVE** time to undergo compensatory adaptations	**ASSOCIATED WITH** the heart undergoing **adaptive responses,** however it can be **deleterious.**
What does it result from? (causes)	1. cardiopulmonary bypass surgery, 2. acute infection (sepsis). 3. acute myocardial infarction, 4. severe arrhythmias	1. Most common cause of CHF is a heart attack which causes damage to the muscle of left ventricle [2]
Can it be managed?	can often be managed successfully by pharmacological or surgical interventions	Study pharmacology lecture 7 & 8 ☺

Note

(2) This part wasn't mentioned in the slides, but for you to know the different. for further reading about CHF:
• http://www.sign.ac.uk/pdf/pat95.pdf (page 4)
• http://www.sign.ac.uk/pdf/sign95.pdf (page 1)

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	RIGHT-SIDED HF	LEFT-SIDED HF
SIGNS & SYMPTOMS Pitting Edema (Legs, Hands)	Moderate to severe	Mild to moderate.
Fluid Retention	Abdomen (ascites[1]).	• Pulmonary edema (fluid in lungs) • pleural effusion (fluid around lungs).
Organ Enlargement	• Liver. (Hepatomegaly) • Mild jaundice may be present.	Heart
Neck Veins	SEVERE jugular venous pressure (JVP). Neck veins visibly distended.	Mild to moderate raised jugular venous pressure (JVP).
Shortness of Breath	Dyspnea present but **not as prominent.**	• Prominent dyspnea. • Paroxysmal nocturnal dyspnea (PND). • Orthopnea [2]
Gastrointestinal	Symptoms are significantly more prominent than LVF • Loss of appetite. • Bloating. • Constipation.	Present but **not as prominent.**
Assessed	Jugular venous pressure which can be accentuated by the hepatojugular reflux	Additional signs indicating **left ventricular failure** include: • Displaced apex beat (due to heart enlargement) • gallop rhythm (additional heart sounds) marker of increased blood flow, or increased intra-cardiac pressure

Note

(1) **Ascites;** the accumulation of fluid in the peritoneal cavity, causing abdominal swelling.
(2) **Orthopnea :**shortness of breath which occurs when lying flat

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Right-sided failure

- Commonly it's secondary to LVF
- If the right ventricular failure due to primarily problem in the lung it's called **COR PULMONALE** (when you have RVF **WITHOUT** LVF)
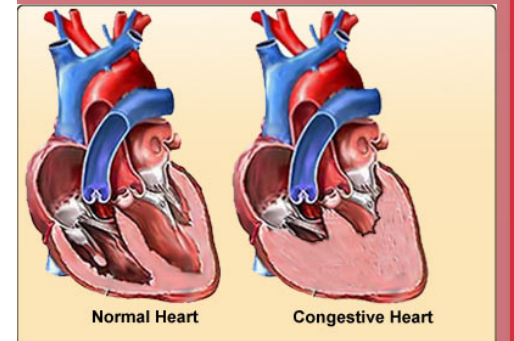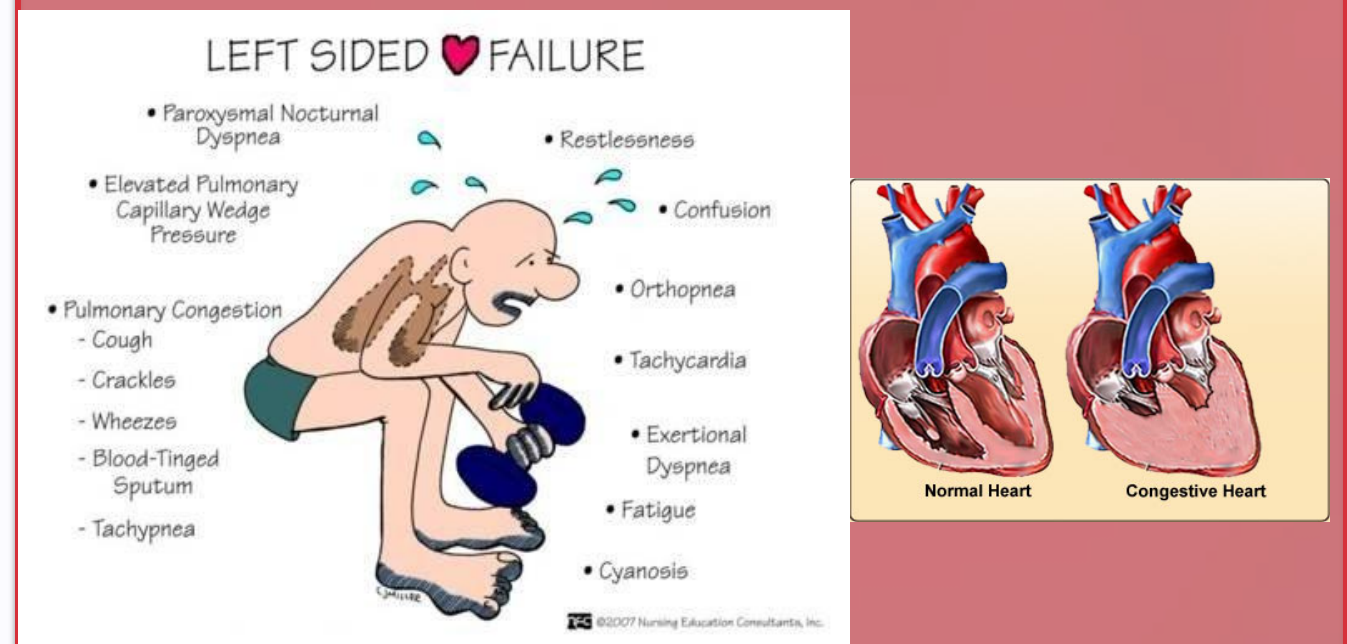
Left-sided failure

Respiratory signs are common due to :
- pulmonary congestion and
- low CO

Which will lead to the mentioned symptoms

1. Tachypnea ⬆ work of breathing.
2. pulmonary edema fluid in the alveoli
3. Cyanosis suggests severe hypoxemia & is a late sign of extremely severe pulmonary edema.
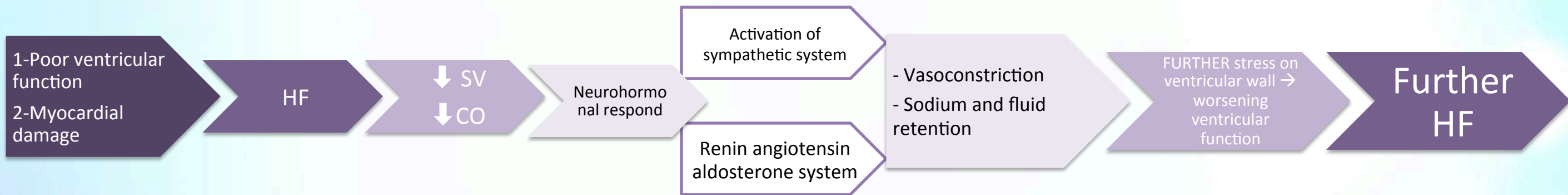
...etc (previous slide)

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1-Poor ventricular function
2-Myocardial damage
→ HF → ↓ SV ↓ CO → Neurohormonal respond →

Activation of sympathetic system

Renin angiotensin aldosterone system

→ - Vasoconstriction
- Sodium and fluid retention

→ FURTHER stress on ventricular wall → worsening ventricular function

→ Further HF

EFFECT OF NATRIURETIC PEPTIDE

Stretch or ↑ in cardiac volume → Release → Natriuretic peptides →

- Vasodilation
- Sodium and fluid excretion
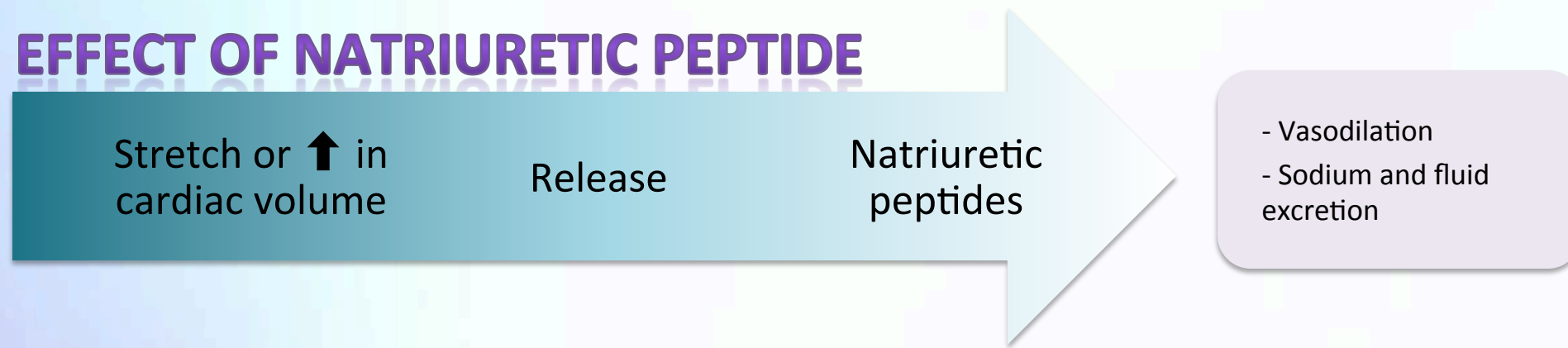
	Responses	Short-term effects	Long-term effects
CONSEQUENCES TO THE NEUROHORMONAL RESPONSES TO IMPAIRED CARDIAC PERFORMANCE	Salt & water retention	Increase preload	• Pulmonary congestion • Systemic congestion
	Vasoconstriction	Maintain BP for perfusion of vital organs	• Exacerbate pump dysfunction by increasing afterload • Increase cardiac energy expenditure
	Sympathetic stimulation	Increase heart rate and ejection	• Increase energy expenditure, • Risk of dysrrhythmia, • Sudden death

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SUMMARY

Explain how cardiac contractility affect stroke volume.

sympathetic stimulation

Or Changes in **heart rate and rhythm→**

Effect **contractility of the myocardium→**

myocardium exerts a major influence on SV

Calculate CO using Fick's principle equation.

$$CO = \frac{VO_2}{CaO_2 - CvO_2}$$

VO_2 =oxygen consumption in ml

CO = Cardiac Output,

C_a = Oxygen concentration of arterial blood.

C_v = Oxygen concentration of mixed venous blood.

Explain pathophysiology of heart failure and differentiate between left and right failure.

When there is a problem in the Contractile state of the myocardium

Or Preload of the ventricle

Or Afterload applied to the ventricle

Or Heart Rate → systolic and /or diastolic function of the heart is impaired → ventricular dysfunction →heart failure

There are differences between right and left HF regarding

1.causes,

2.effect on body systems and

3.clinical manifestations

Explain how the pathophysiology associated with heart failure results in typical signs and symptoms.

Fluid "backs up" in the lungs → Persistent Cough or Wheezing

Blood returning to the heart from the veins "backs up" causing fluid to build up in tissues →Edema

Heart can't pump enough blood to meet needs of bodies tissues →Tiredness, fatigue

MCQS
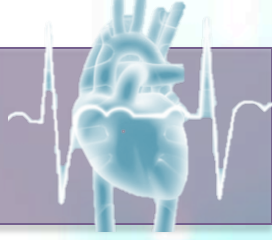
1- The term "heart failure" means the heart has stopped working.
A. True
B. False

2- 44 years old women came to the ER having a HF and her Physical examination reveals pitting peripheral edema, ascites, and hepatomegaly. Which mostly type of ventricular failure she is having ?
A. RVF
B. LVF
C. BVF

3- In Right HF fluid accumulate in the lung because the kidney receives more blood, which causes the kidney to keep the water in the blood
A. True
B. False

4- After a heart attack the person is more likely to have HF
A. True
B. False

5- when you examine a patient with HF and you hear gallop rhythm, which type of ventricular failure it indicates?
A. RVF
B. LVF
C. BVF

6- In acute HF the heart undergoing adaptive responses :
A. True
B. False

7- Cor pulmonale is a term used when we have biventricular HF
A. True
B. False

8- one of the long term consequences of neurohormonal responses of Sympathetic stimulation is:
A. Systemic congestion
B. Increase cardiac energy expenditure
C. Sudden death

Answers: 1:B   2:A   3:B   4:A   5:B   6:B   7:B   8:C

Done By: Sara Alkharashi   **Revised By:** Mojahed Otayf