CVS Block
Jugular Venous Pulse
Heart Failure

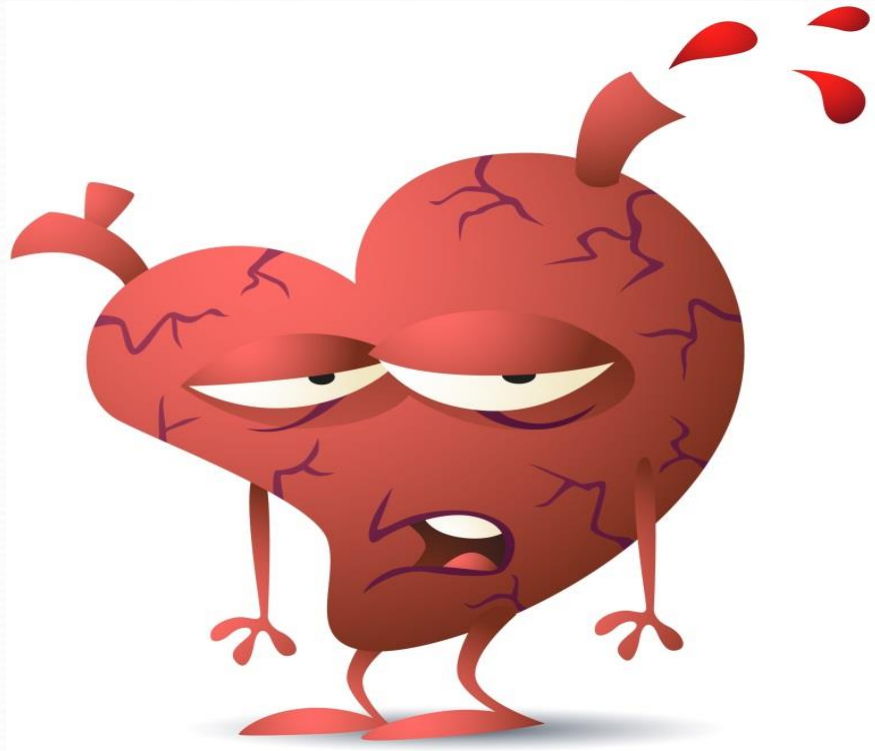
(Physiology L No.8)

Dr. Hayam Gad

MBBS, MSc, PhD

A. Professor of Physiology

College of Medicine, KSU



Learning Objectives

- Identify the jugular venous pressure
- Know the method of examination of the internal venous pressure
- Normal pattern of the jugular venous pulse
- What are the abnormalities of jugular venous pulse
- Define heart failure
- Identify types of heart failure
- Describe the causes and pathophysiological consequences of acute and chronic heart failure.
- Indicators for diagnosis of heart failure
- Explain how left-sided failure leads to right-sided failure & congestive heart failure.
- Discuss the compensatory mechanisms in heart failure.
- Summarize clinical picture of left-sided and right-sided failure.
- Interpret and draw Starling curves for healthy heart, acute heart failure, and heart failure treated with digoxin.

What are the Jugular Venous Pulse and Pressure?:

- **Jugular Venous Pulse:**

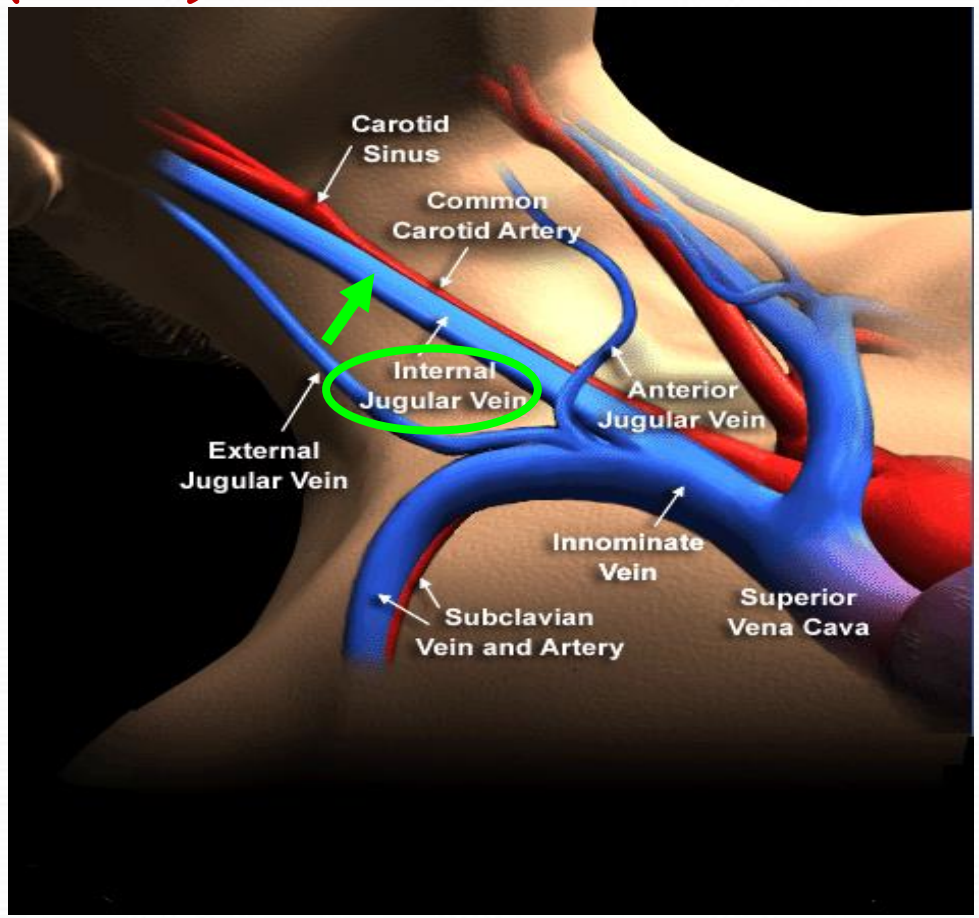
  It is the ***oscillating top*** of the vertical column of blood in the ***right internal jugular vein*** that reflects pressure changes in right atrium during the cardiac cycle.

- **Jugular Venous Pressure:**

  It is the ***vertical height*** of the oscillating column of blood in the ***right internal jugular vein***.

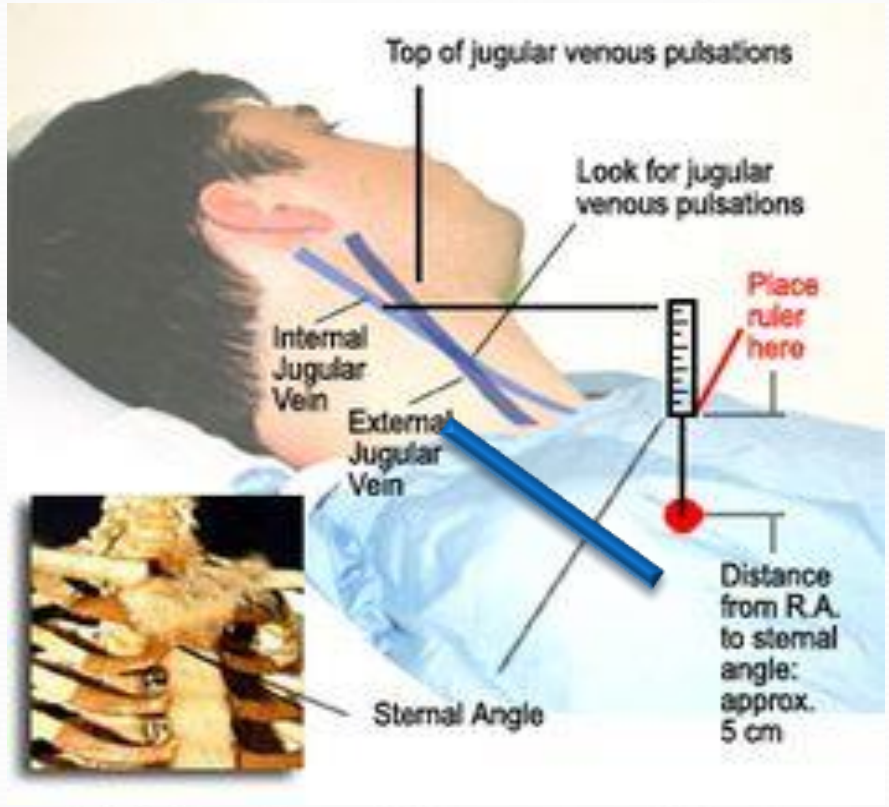
Why Right Internal Jugular Vein (IJV)?

- IJV extend in an almost straight line to superior vena cava and has a direct course to the right atrium (RA), thus favoring transmission of the hemodynamic changes from RA.
- IJV is anatomically closer to RA.
- IJV has no valves (valves in EJV prevent transmission of RA pressure)
- The left innominate vein is not in a straight line and may be kinked or compressed between aortic arch and sternum, by a dilated aorta, or by an aneurysm.



Method Of Examination

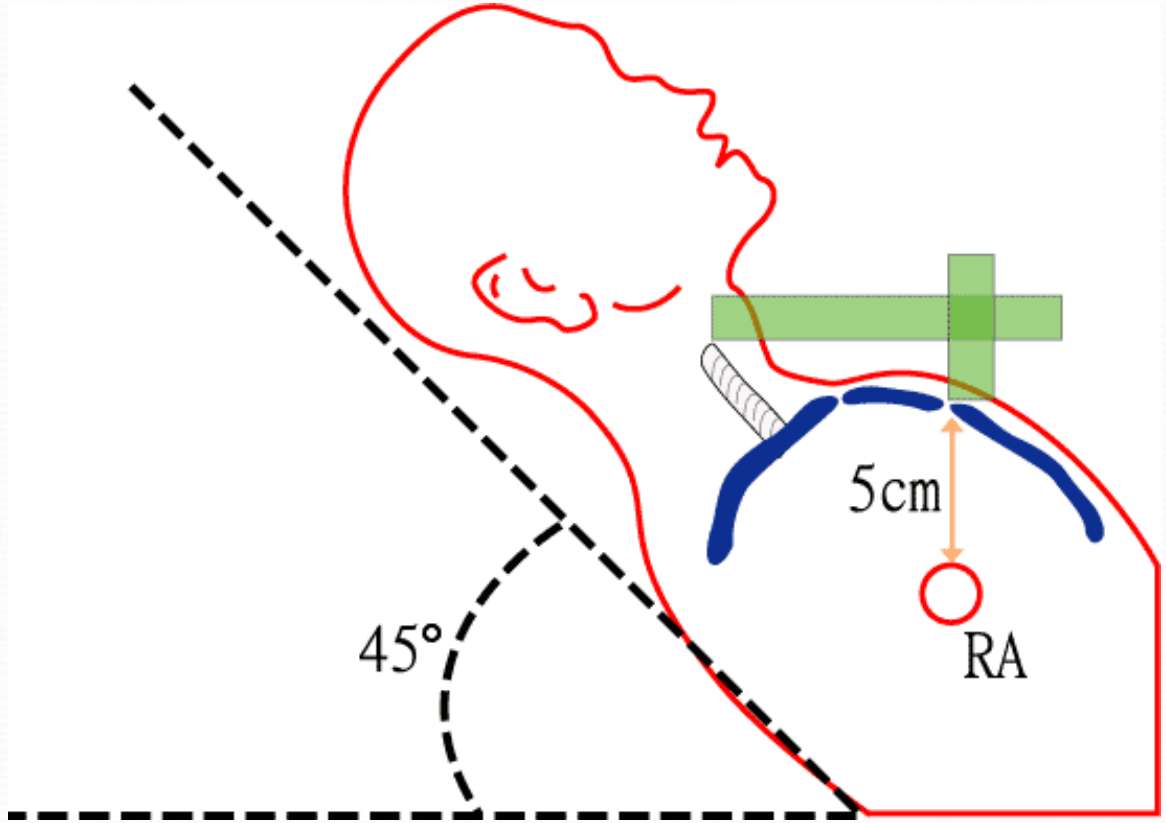
- The patient should lie comfortable during the examination.
- Clothing should be removed from the neck and upper thorax.
- Patient reclining with head elevated 45 °.
- Neck should not be sharply flexed.
- Examined effectively by shining a light across the neck.
- There should not be any tight bands around abdomen.



Observations Made

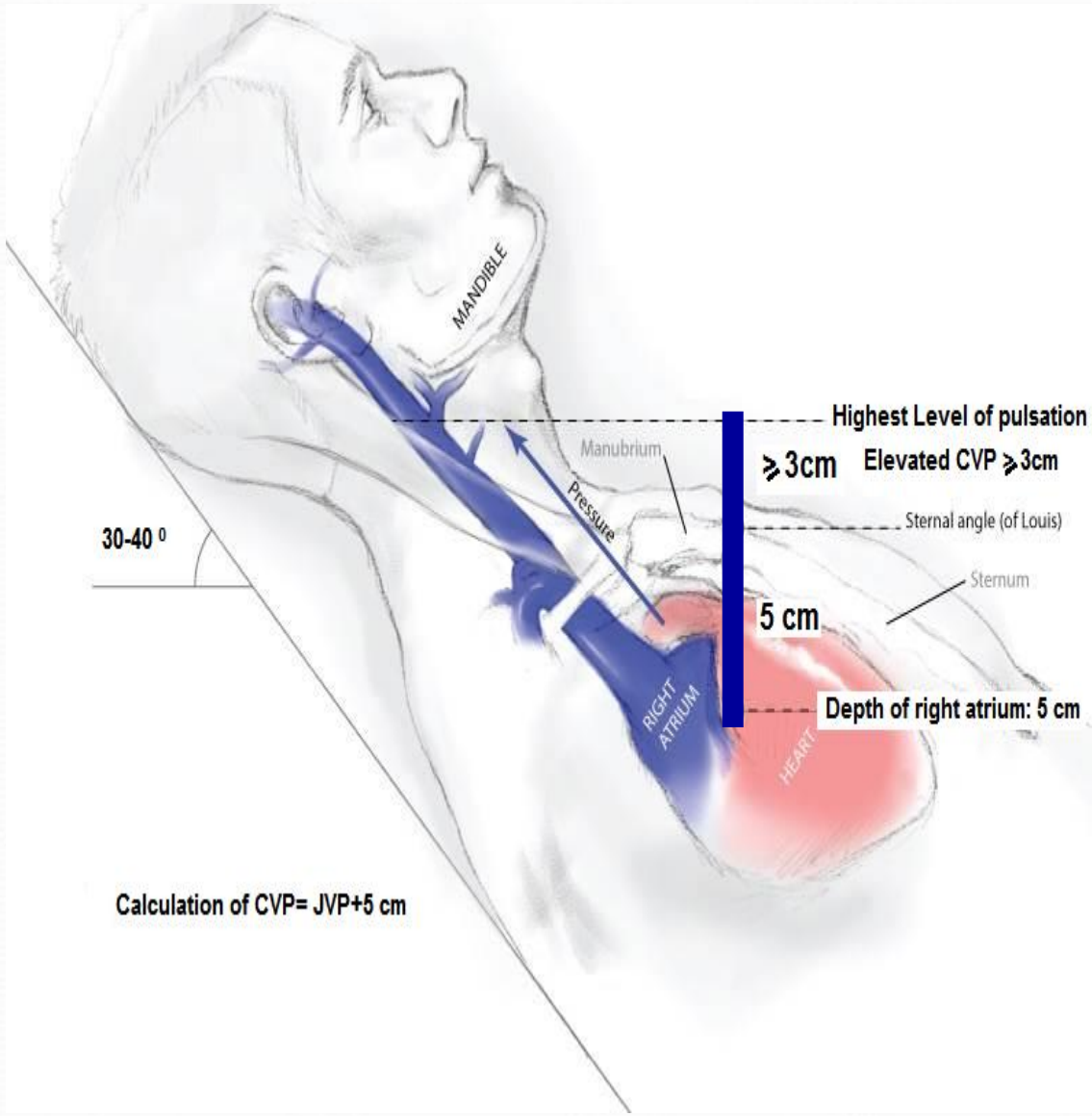
When the patient reclining with head elevated 45 °, observe:-

- **The level of venous pressure.**
- **The type of venous wave pattern.**

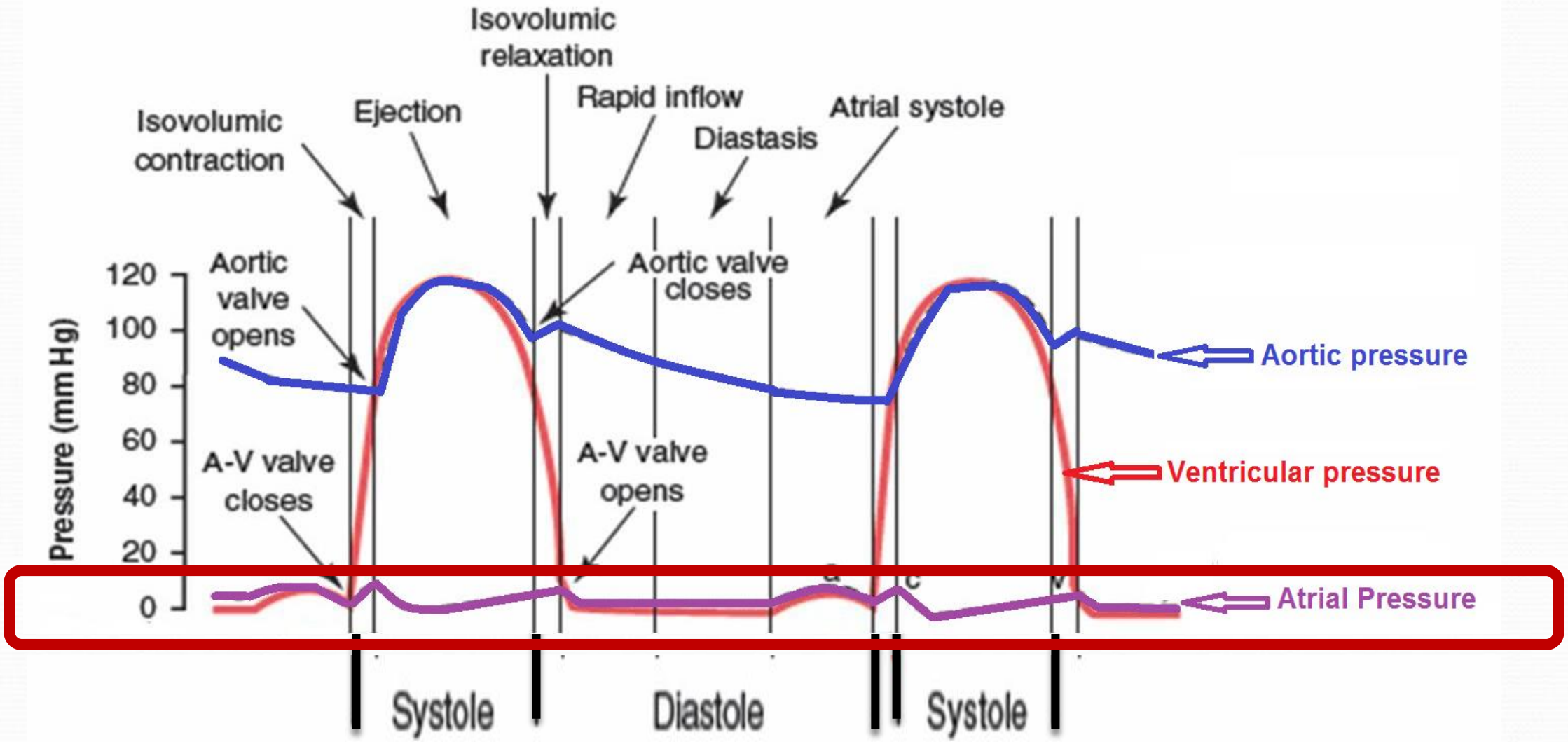


The level of venous pressure

- Using a centimeter ruler, measure the vertical distance between the angle of Louis and the highest level of jugular vein pulsation.
- The upper limit of normal is 3 cm above the sternal angle.
- Add 5 cm to measure central venous pressure since right atrium is 5 cm below the sternal angle.
- Normal CVP is < 8 cm H_2O

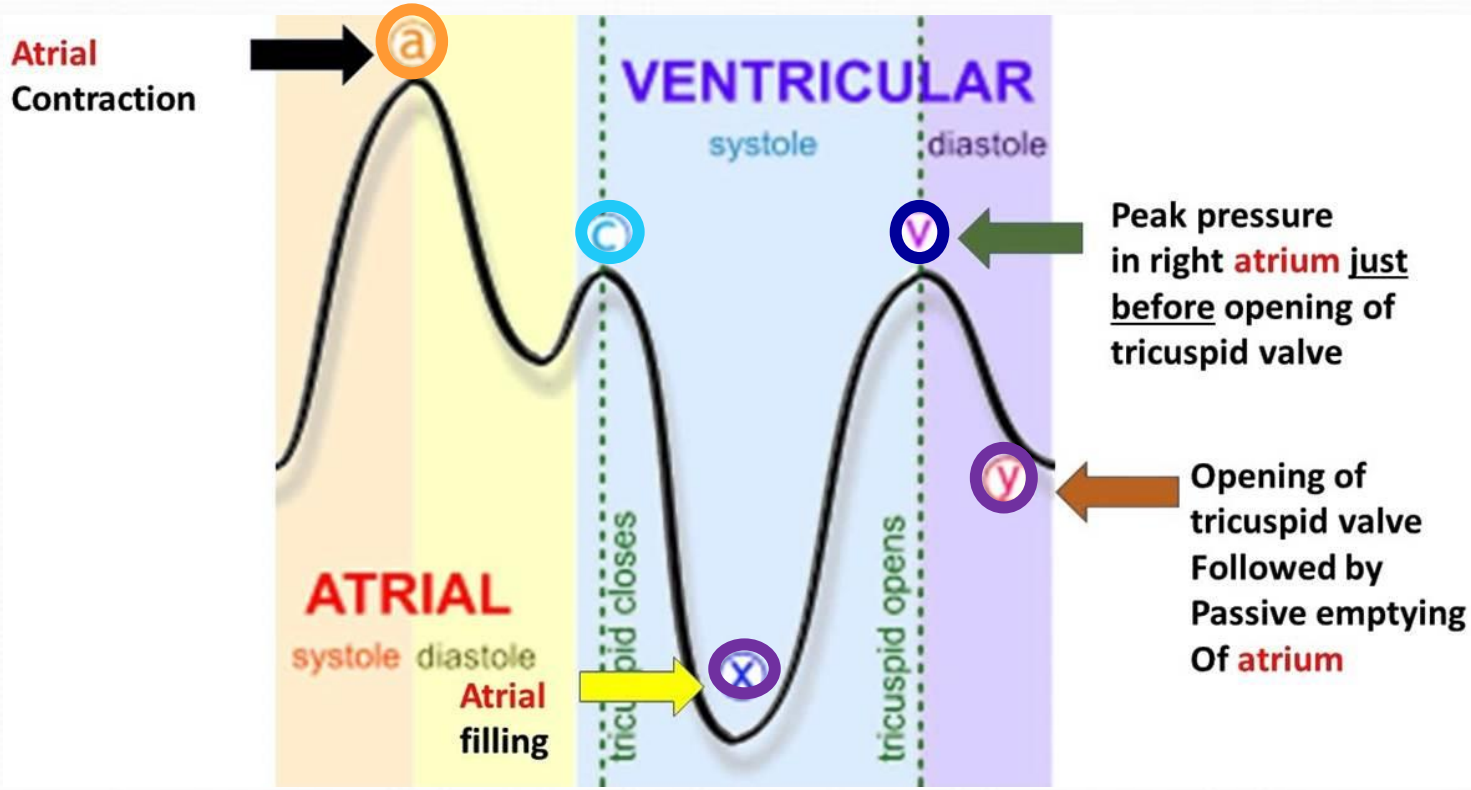


Atrial Pressure Changes During Cardiac Cycle

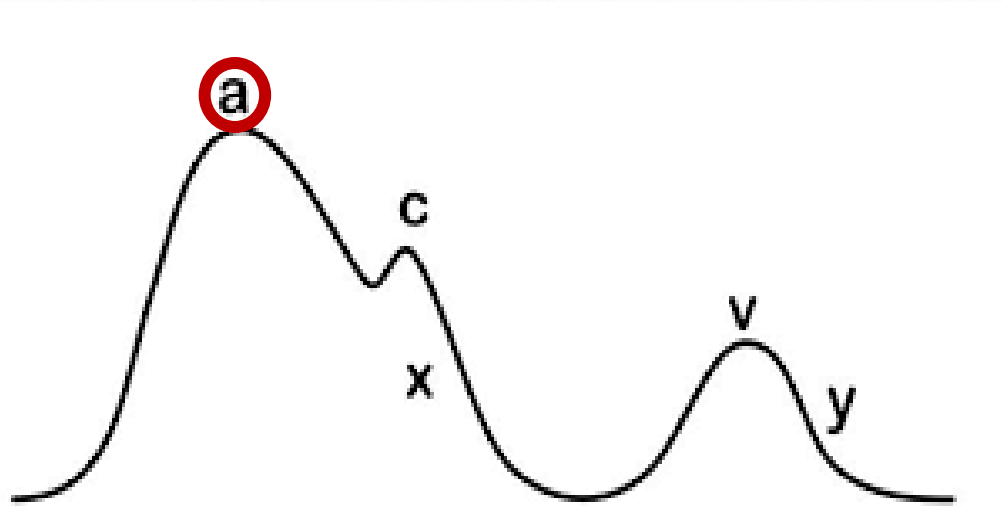


Normal pattern of the jugular venous pulse (Atrial pressure changes during the cardiac cycle)

- The normal JVP reflects phasic changes in right atrial pressure (RAP). It consists of:
  - Three positive waves (a, c, & v waves)= (↑ atrial pressure)
  - Two negative waves or descents (x & y waves)= (↓ atrial pressure)
  - These 3 waves are equal to ONE cardiac cycle = 0.8 sec



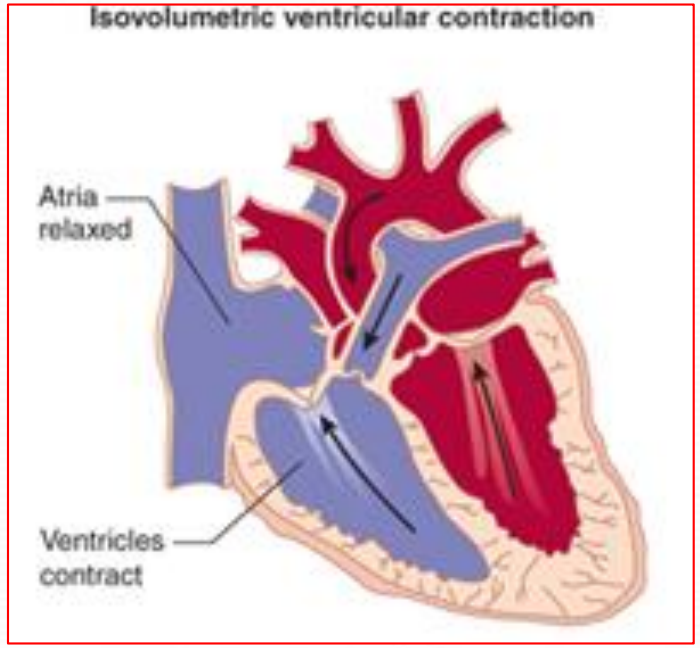
The "a" Wave: Atrial systole

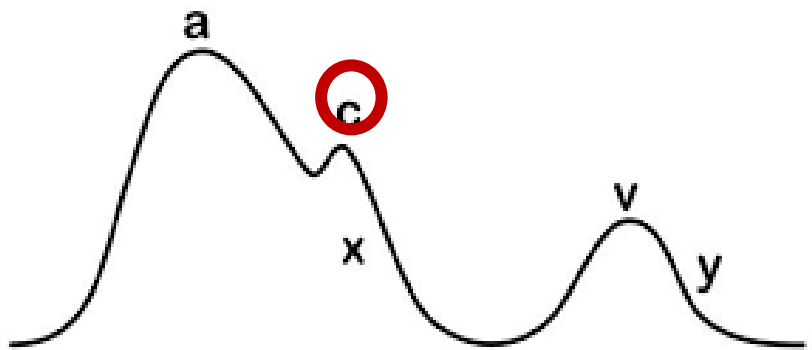


- It represents the increase in right atrial pressure secondary to right atrial contraction occurring at the end of ventricular diastole.

The "c" wave: Ventricular systole

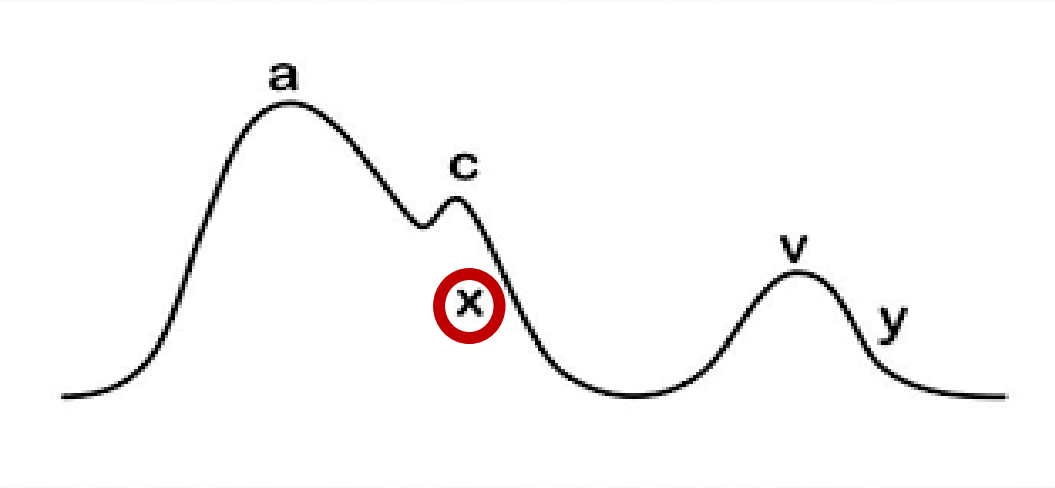
- It represents the increase in right atrial pressure caused by the bulging of tricuspid valve into the right atrium during isovolumetric ventricular contraction. Or due to transmitted carotid pulsations.

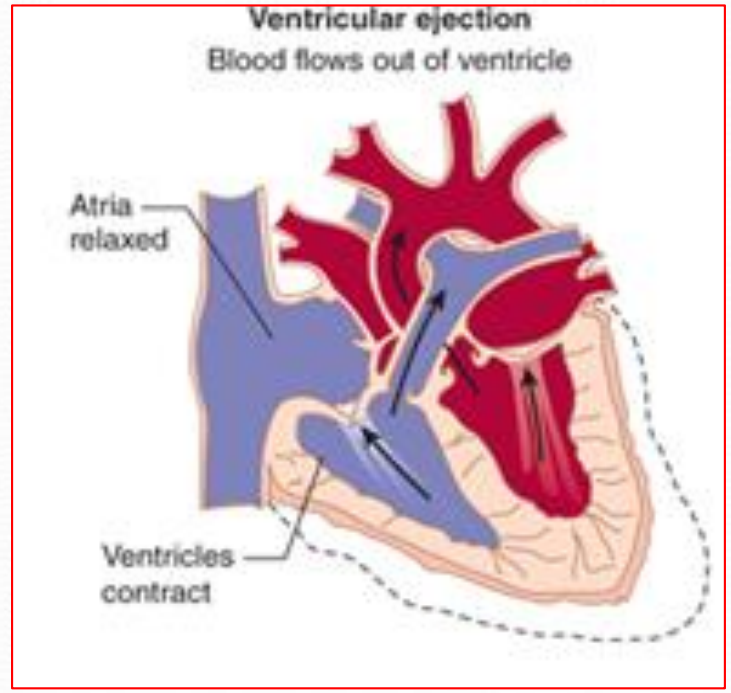




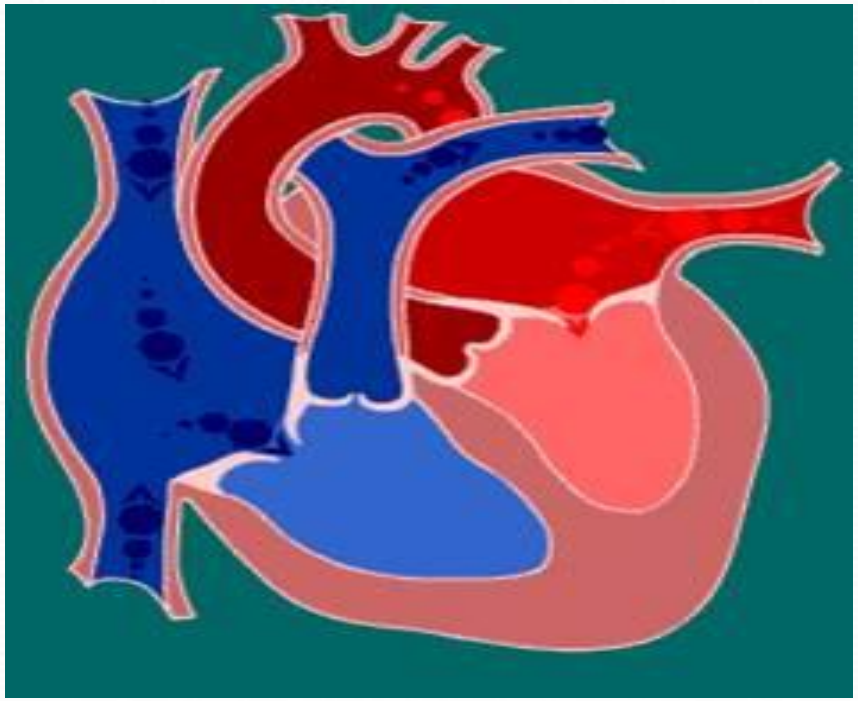
The "x" descent:

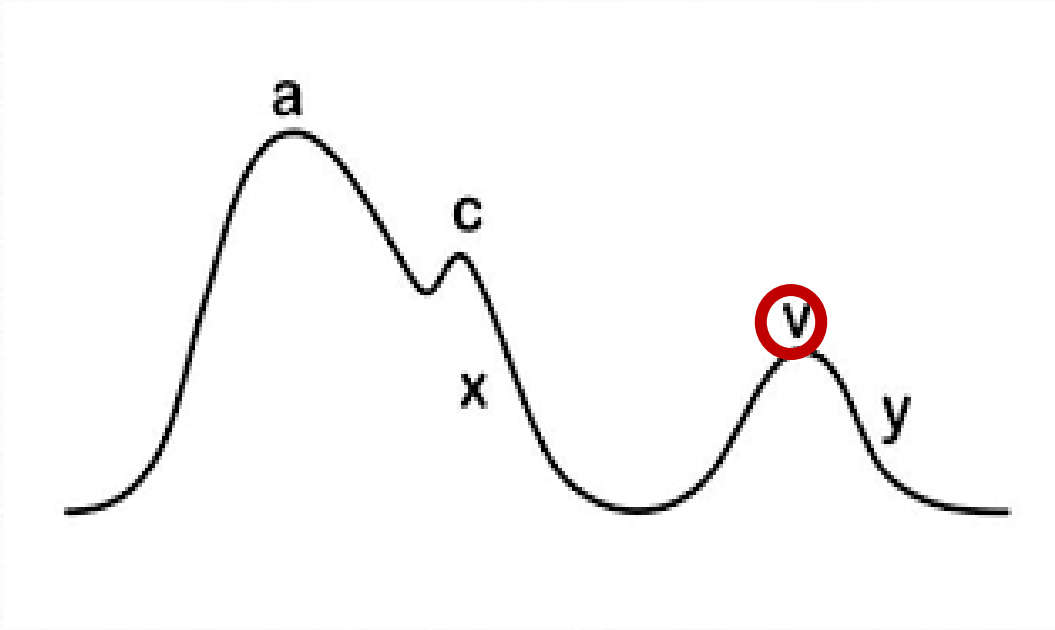
- It represents the decrease in right atrial pressure due to atrial relaxation and downward displacement of tricuspid valve secondary to contraction of papillary muscles during ventricular systole (ejection phase).





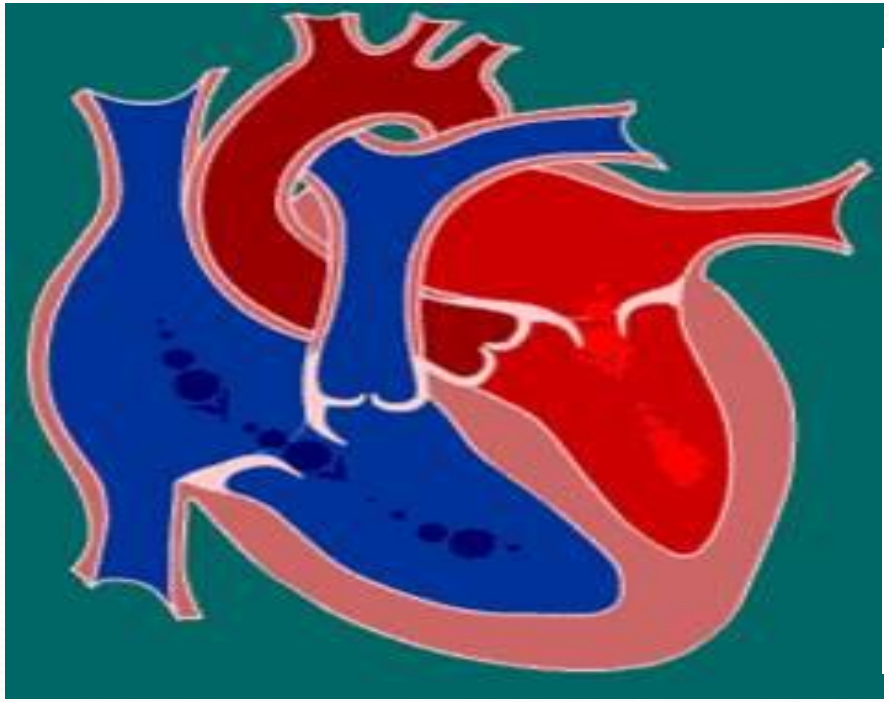
"v" Wave:

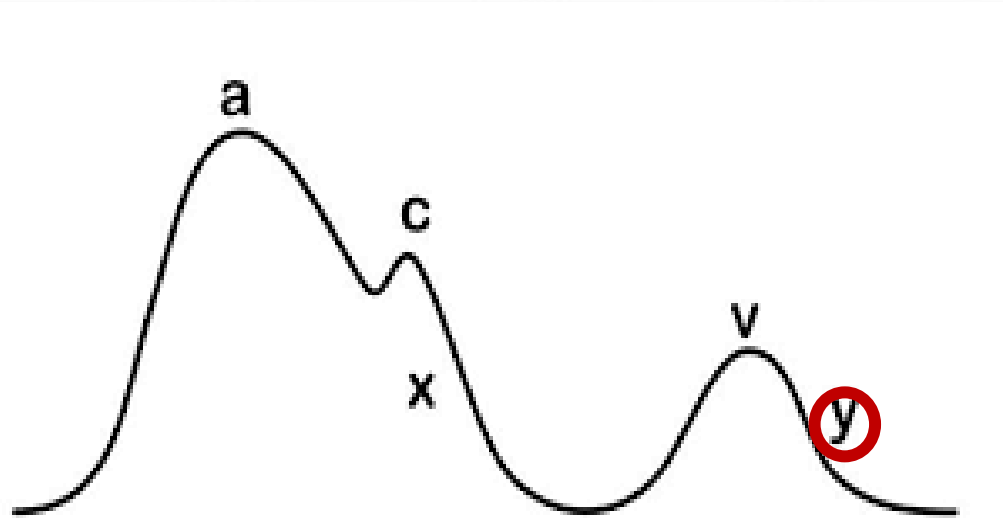




- It represents the increase in right atrial pressure as it fills with blood returning from the great veins against a closed tricuspid valve during atrial diastole.

"y" Descent

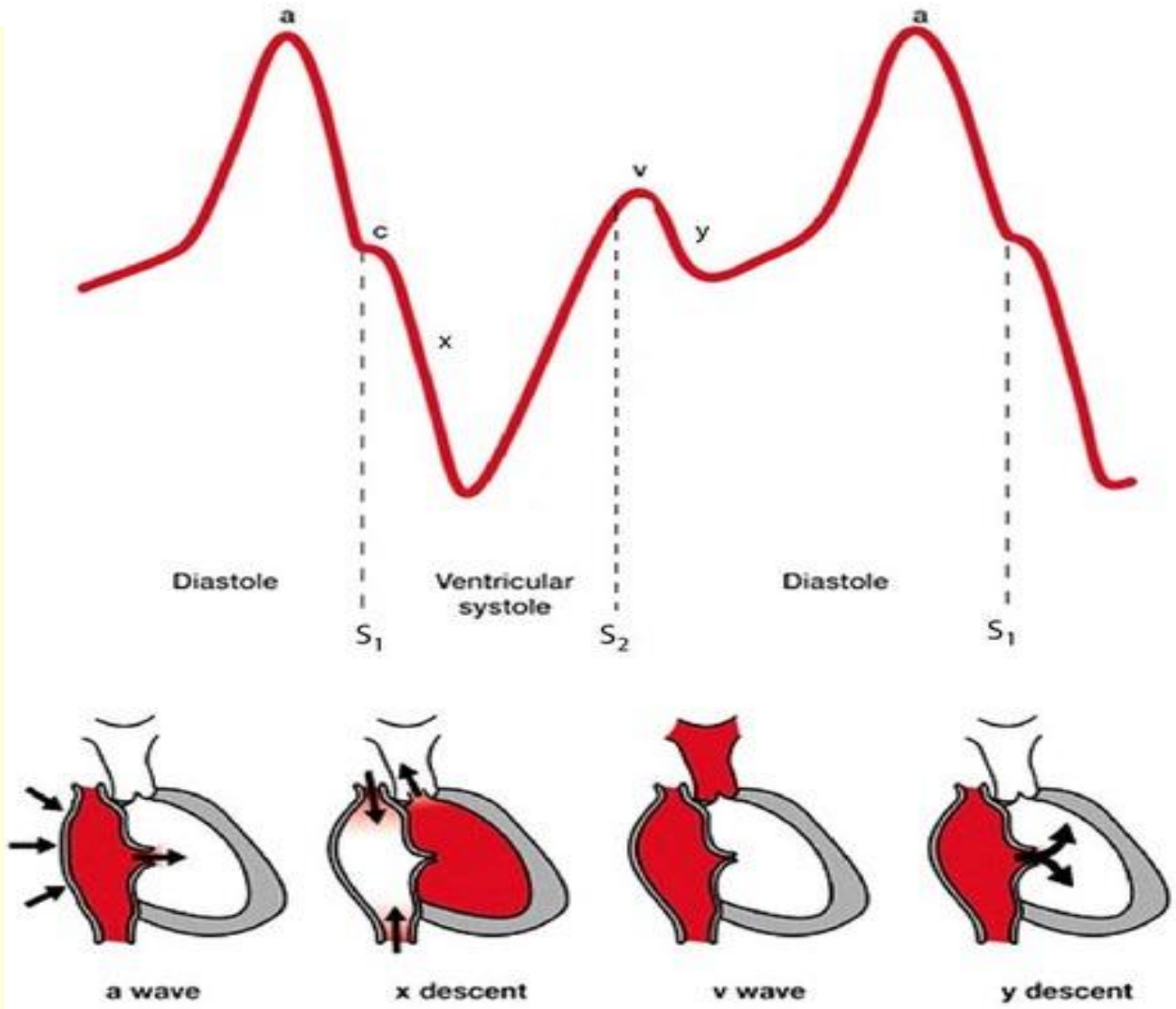




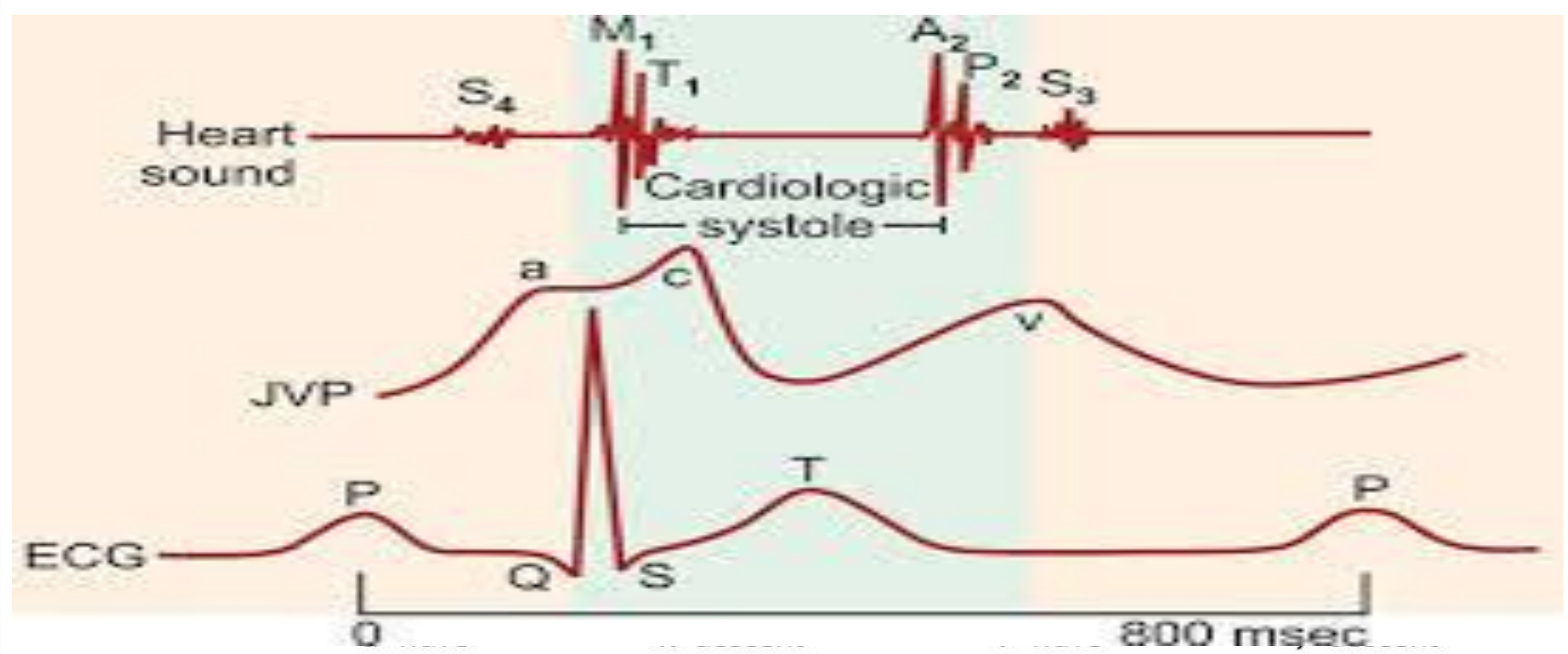
It represents the fall in right atrial pressure as blood flows out of the right atrium into the right ventricle upon opening of the tricuspid valve during the filling phase.

Summary: Causes of the Normal Waves of JVP

Wave name	Physiologic event
'a' wave	Increased right atrial pressure secondary to right atrial contraction occurring at the end of ventricular diastole.
'c' wave	Increased right atrial pressure caused by the bulging of tricuspid valve into the right atrium during isovolumetric ventricular contraction. Or due to transmitted carotid pulsations.
'x' descent	Decreased right atrial pressure due to downward displacement of tricuspid valve secondary to contraction of papillary muscles during ventricular systole.
'v' wave	It represents the increase in right atrial pressure as it fills with blood returning from the great veins against a closed tricuspid valve.
'y' descent	It represents the fall in right atrial pressure as blood flows out of the right atrium and into the right ventricle upon opening of the tricuspid valve.



Correlation of JVP with ECG & Heart Sounds



A simultaneous recording of the JVP and ECG shows the P wave in the ECG occurs just before the ‘a’ wave of JVP, thus showing atrial depolarization precedes the atrial contraction.
S1 occurs at the beginning of the ‘c’ wave,
S2 occurs at the beginning of the ‘v’ wave

Abnormalities of Jugular Venous Pulse

A- Low jugular venous pressure

1. Hypovolemia.

B- Raised Jugular Venous Pressure

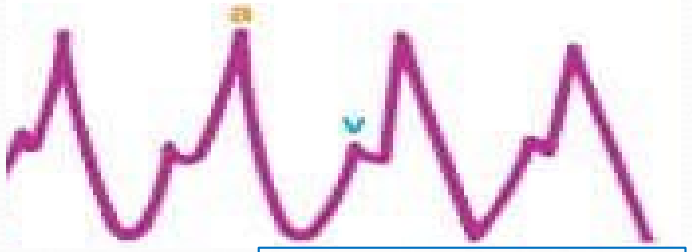
1. Increased right ventricular filling pressure e.g. in heart failure, fluid overload.
2. Obstruction of blood flow from the right atrium to the right ventricle e.g. tricuspid stenosis.
3. Superior vena caval obstruction e.g. retrosternal thyroid goiter.
4. Positive intrathoracic pressure e.g. pleural effusion, pneumothorax.

N.B: The JVP usually drops on inspiration along with intrathoracic pressure.

Abnormalities of "a" Wave

- **Absent 'a' wave**
  - Atrial fibrillation or atria flutter
- **Elevated, Giant'a' wave, uniform, every beat**
  - Right atrial hypertrophy
  - Tricuspid stenosis
  - Decreased ventricular compliance (ventricular failure, pulmonary valve stenosis, or pulmonary hypertension)
- **Cannon 'a' wave, intermittent, various height**
  - Atrial-ventricular asynchrony (atria contract against a closed tricuspid valve)
  - Complete heart block
  - Following premature ventricular contraction
  - Ventricular tachycardia
  - Ventricular pacemaker

Absent 'a' wave



Elevated "a' wave

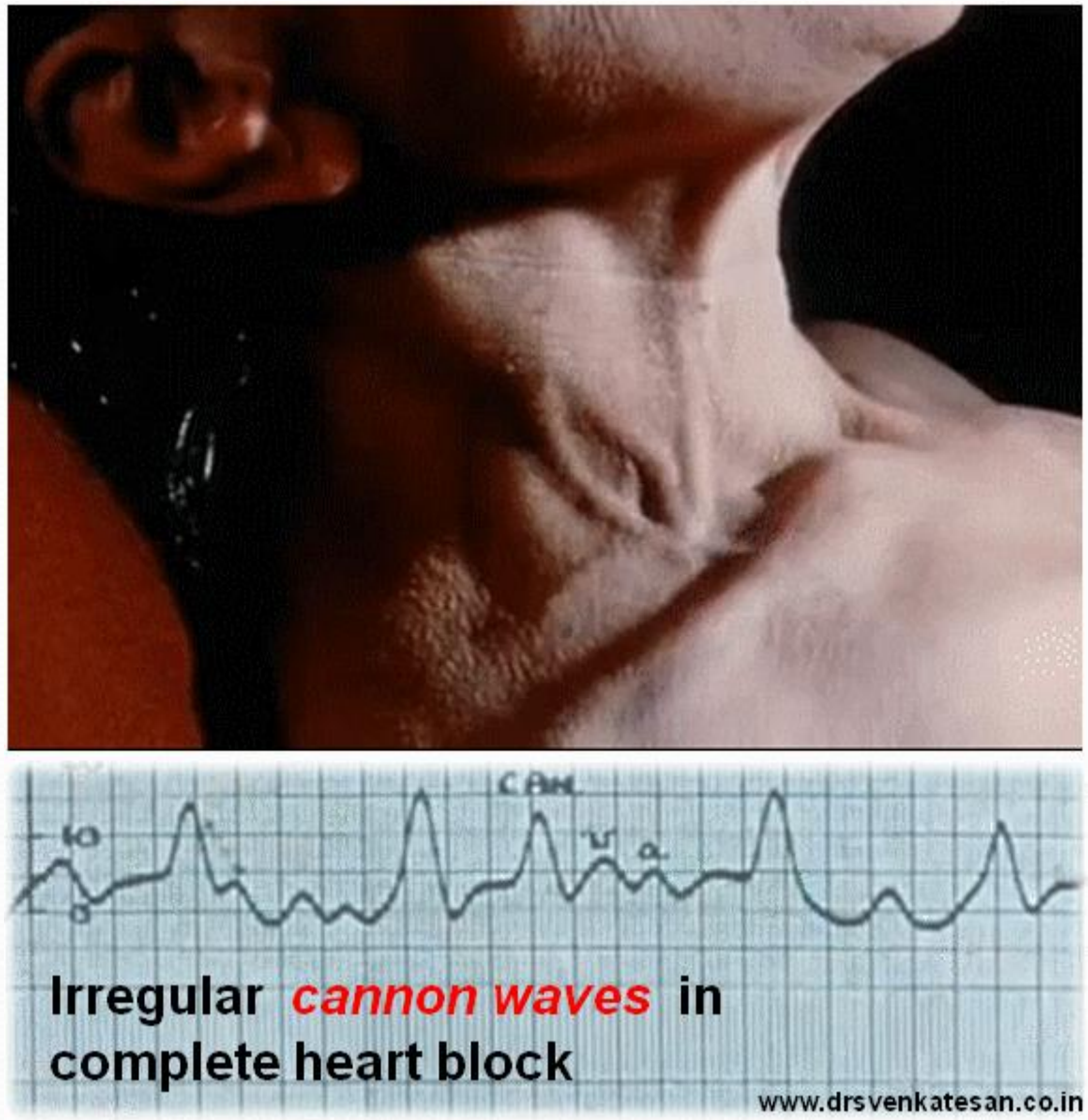
Cannon 'a' wave

Regular Cannon Waves

Regular cannon waves occurs when atria and ventricular contractions occur nearly simultaneously (as in atrioventricularnodal reentrant tachycardia).

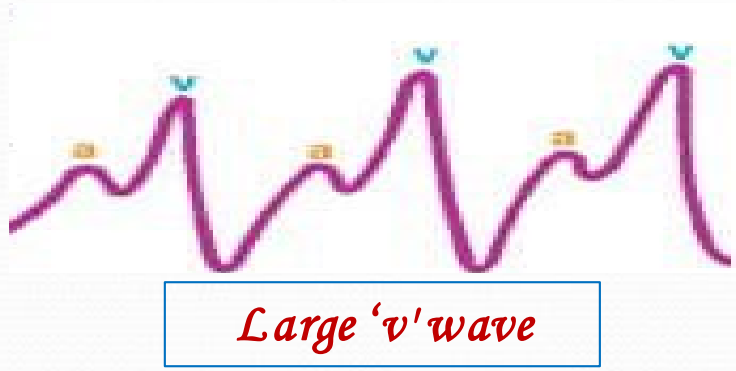
Irregular Cannon Waves

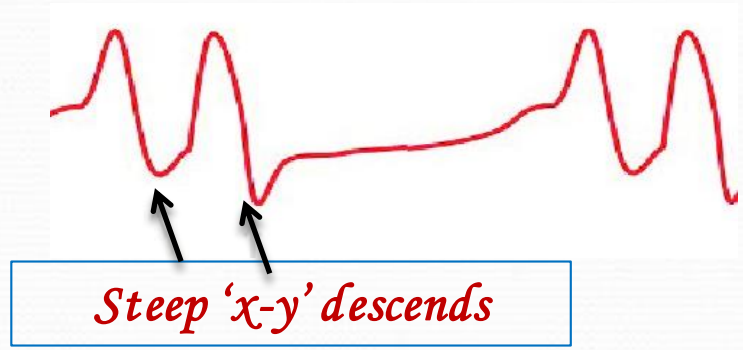
Irregular cannon waves occur in complete heart block

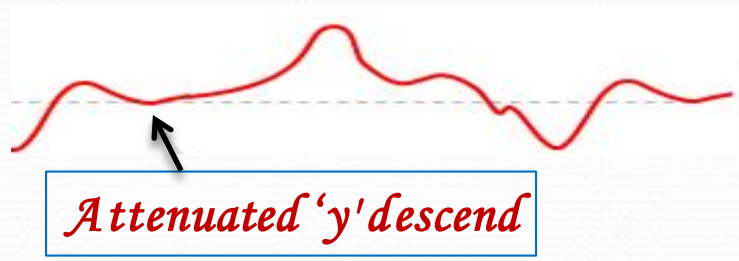


Abnormalities of Other Waves

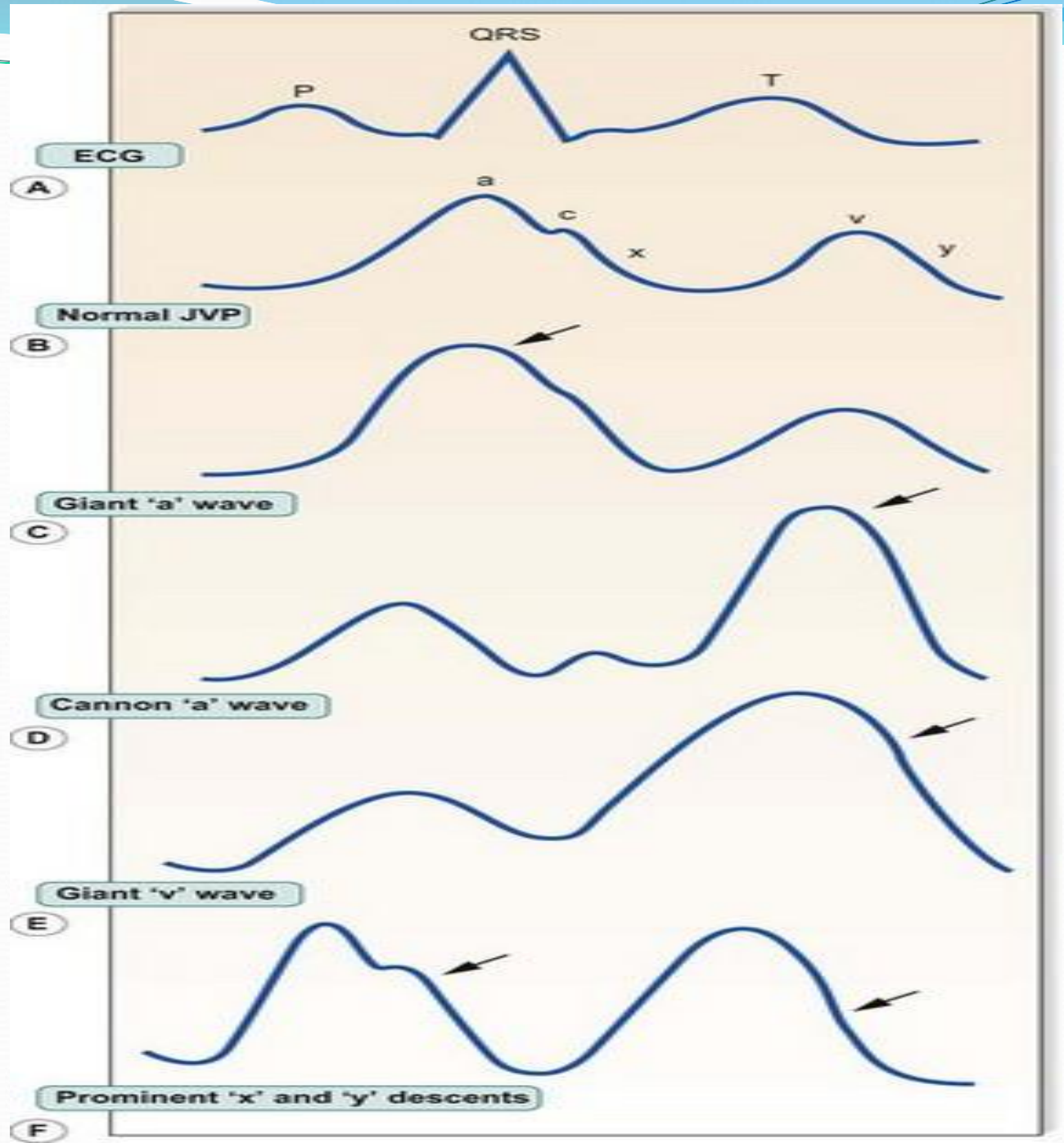
- **Large 'v' wave**
  - Atrial septal defect
  - Tricuspid regurgitation
- **Diminshed 'v' wave**
  - Hypovolaemia
- **Steep 'x-y' descends (Friedrich's sign)**
  - Constrictive pericarditis as it reduces elasticity of pericardial sac, raises AP and limiting ventricular filling in early diastole
- **Attenuated 'y' descend,**
  - Cardiac tamponade as it impedes ventricular filling







Summary: Abnormalities of Jugular Venous Pulse



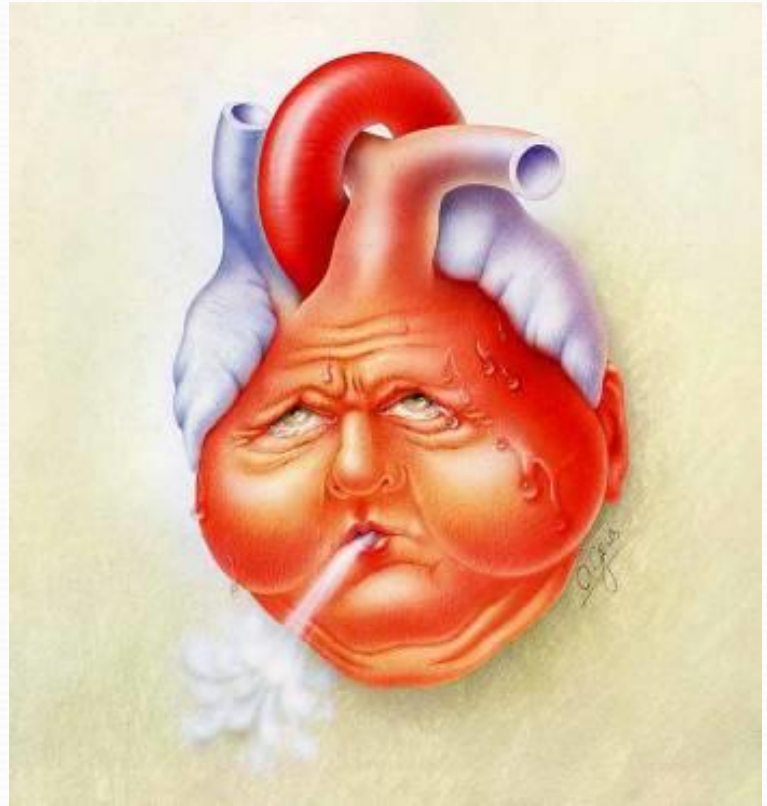
Video for JVP: Waveforms & Their Abnormalities

- https://www.youtube.com/watch?v=TlhzuJIz_8U&ab_channel=AlilaMedicalMedia
- https://www.youtube.com/watch?v=Z4yRBhlKouY&ab_channel=ZeroToFinals

Heart Failure

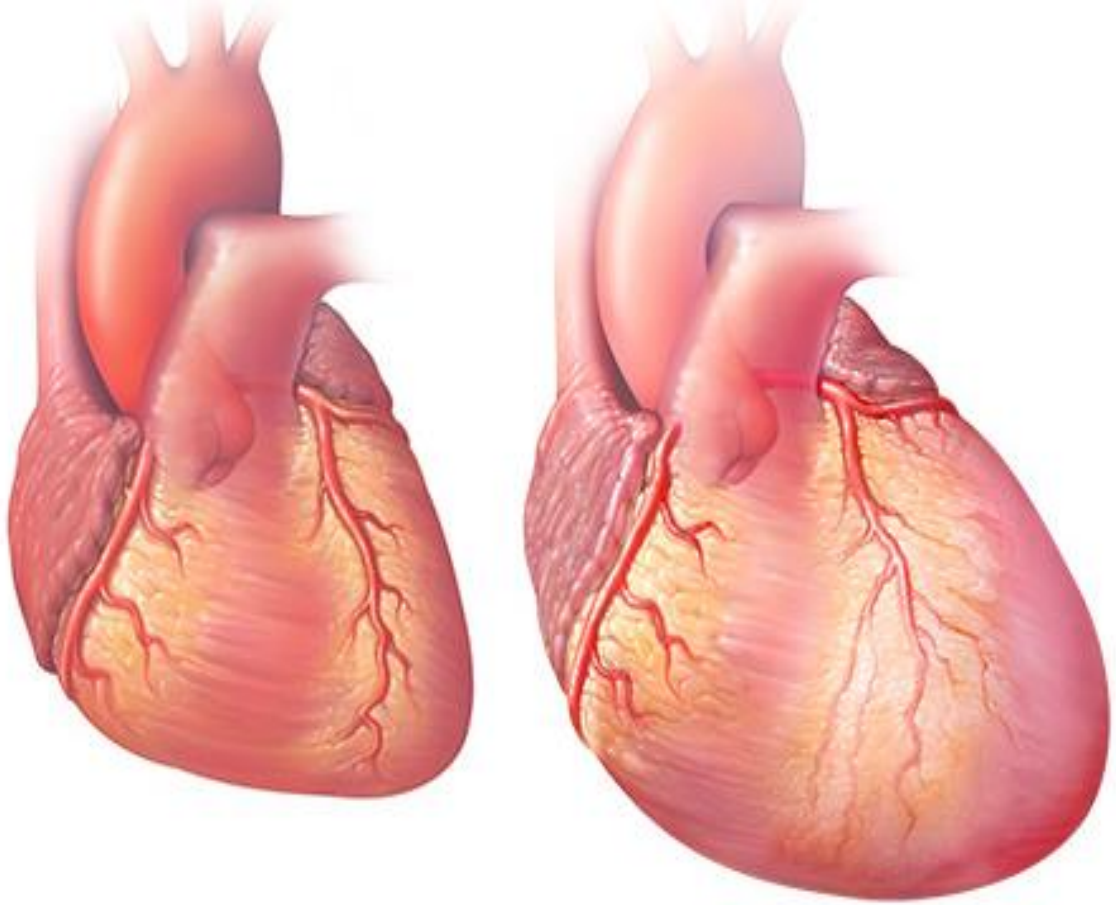
Definition

It is the pathophysiological process in which the heart as a pump is unable to meet the metabolic requirements of the tissue for oxygen and substances despite the venous return to heart is either normal or increased.



How Fast Does Heart Failure Develop?

- ✓ Usually a chronic disease
- ✓ The heart tries to compensate for the loss in pumping function by:
  - Developing more muscle mass
  - Enlarging
  - Pumping faster



Normal Heart

Heart Failure

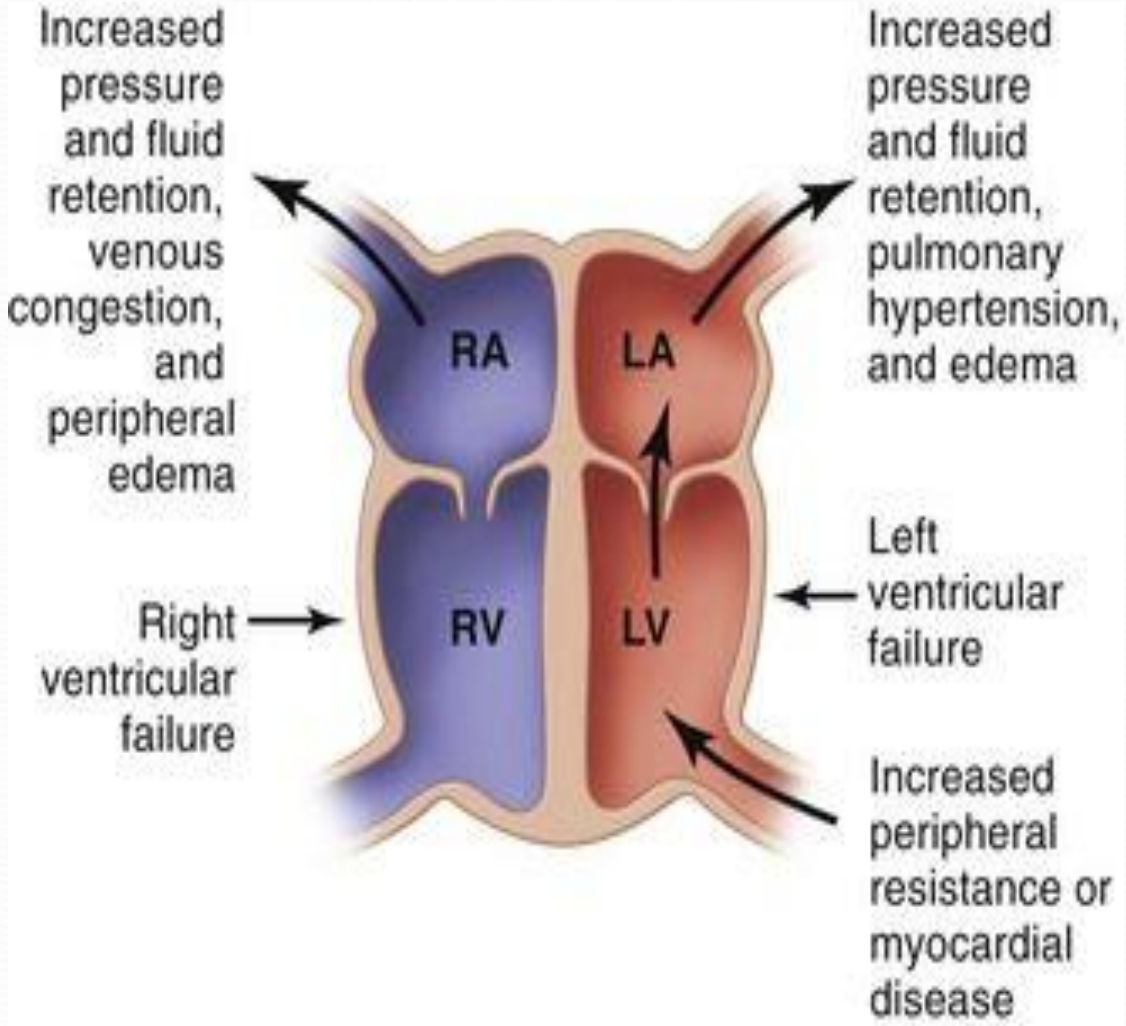
Heart assumes a more spherical shape, enlargement of all 4 chambers

Types of Heart Failure

- Heart failure can involve the left or right side of the heart or both.
- ***Left sided heart failure***

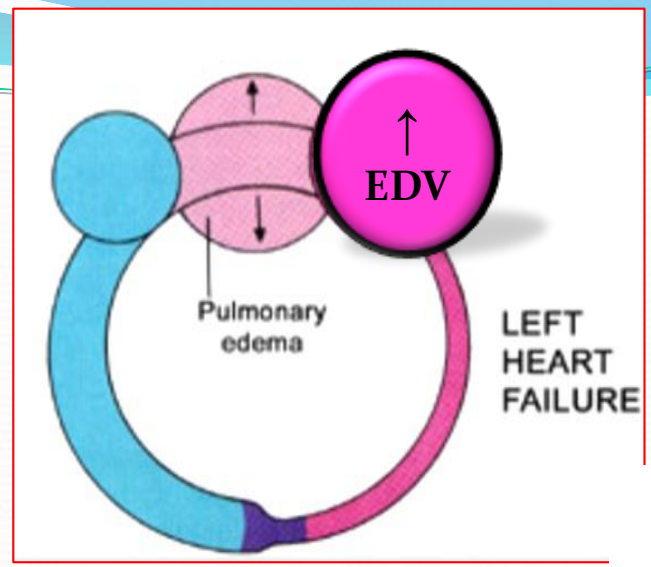
  Inadequate output of LV causing decreased CO to body and back pressure to the lungs. The left side of the heart is usually where heart failure begins.
- ***Right sided heart failure***

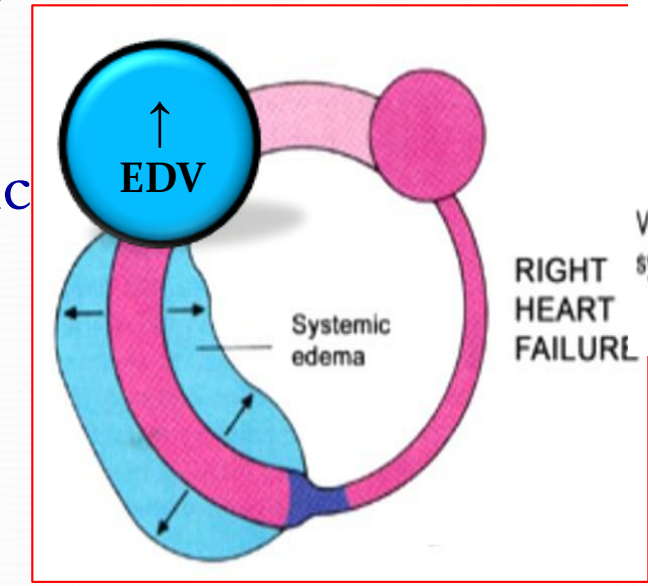
  Inadequate output of RV causing decreased CO to lungs and back pressure to venous system. It may occur alone but is usually a result of left-sided failure.

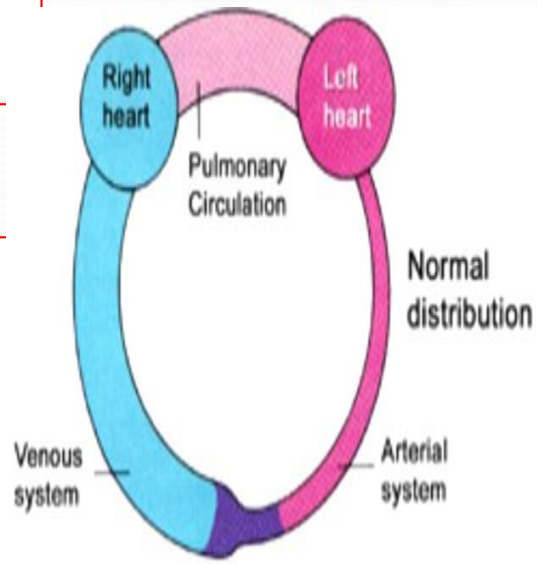


Left vs. Right Heart Failure:

- ***In left-sided failure***, VR from pulmonary circulation is not pumped out by the failing LV → blood accumulates in pulmonary circulation →↑the pulmonary capillary pressure → pulmonary edema
- ***In right-sided failure***, VR from systemic circulation is not pumped out by the failing RV → blood accumulates in systemic circulation → ↑ the systemic capillary pressure → systemic edema.
- Though each side of the heart can undergo failure separately, dysfunction of one side may lead to a sequence of events that make the opposite side also to fail.



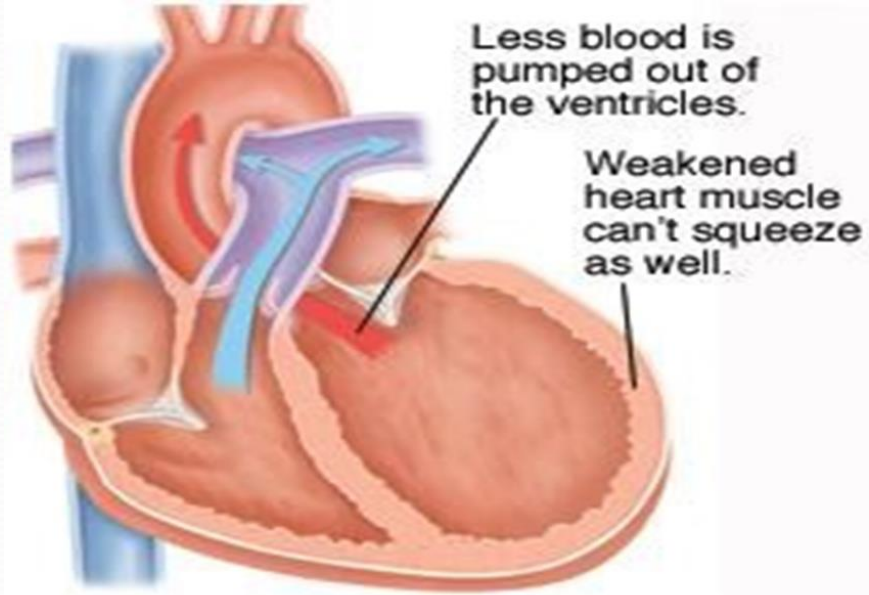




Types of Heart Dysfunction That Lead To HF

- ***Systolic (or squeezing) heart failure***
  - This is the most common cause of HF
  - The muscle of ventricle is weak and enlarged and looses some of its ability to contract or pump the amount of oxygenated and nutrient-filled blood the body needs into the circulation.

N.B: The ejection fraction is lower than normal.

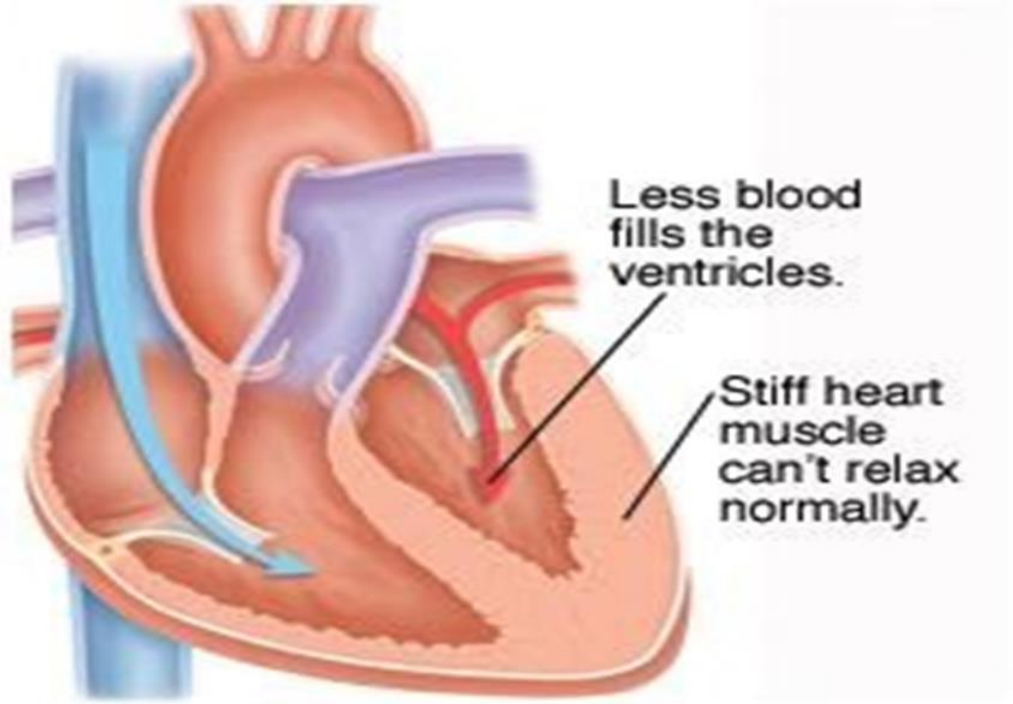


Systolic heart failure. The heart muscle becomes weak and enlarged. It can't pump enough blood forward when the ventricles contract. Ejection fraction is lower than normal.

Types of Heart Dysfunction That Lead To Hf…cont.

- ***Diastolic (or relaxation) heart failure***
  - The heart looses its ability to relax because it becomes stiff. The walls of the heart thicken, and the size of the chamber may be normal or reduced.
  - As a result, the affected chamber cannot fill properly with blood during the rest period that occurs between each heart beat.

N.B: The ejection fraction is often in normal range.

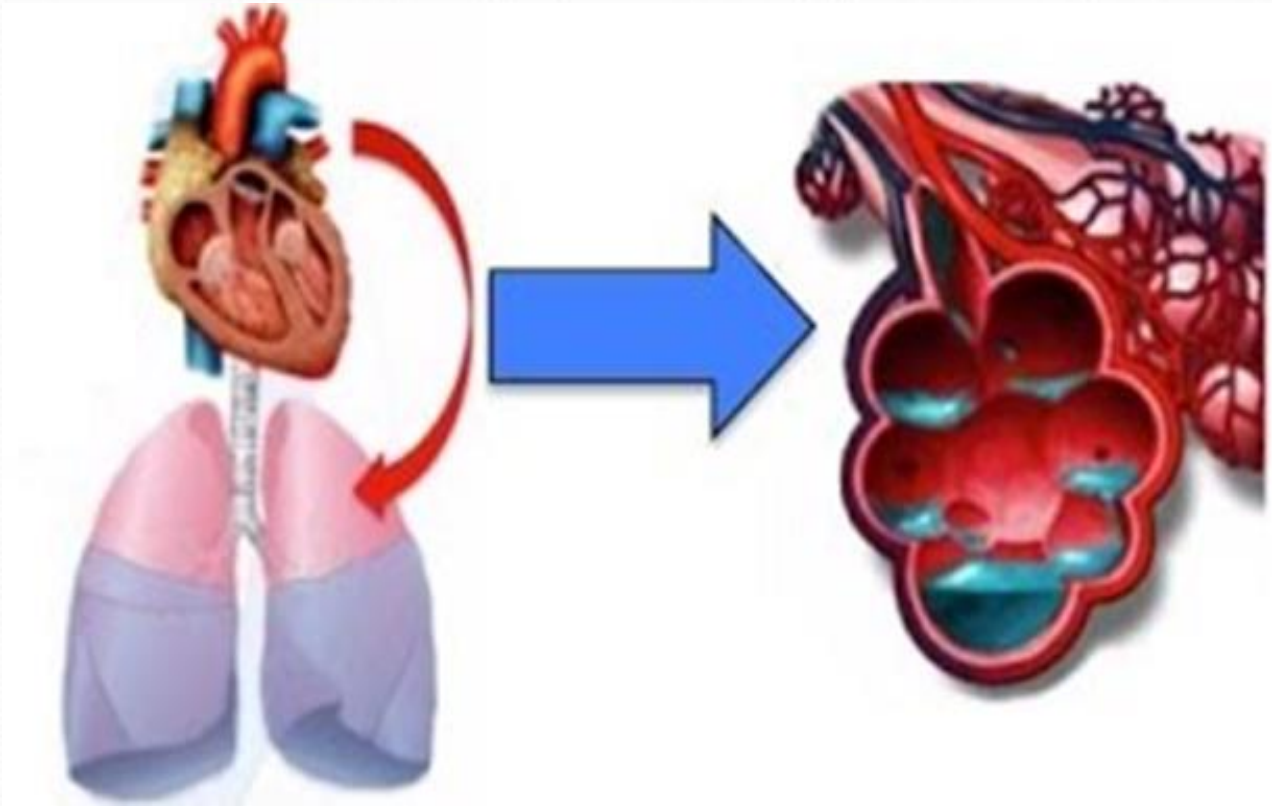


Diastolic heart failure. The heart muscle becomes stiff. It doesn't relax normally between contractions, which keeps the ventricles from filling with blood. Ejection fraction is often in the normal range.

- ***Congestive heart failure***

  Chronic left HF results in:-

  - Secondary pulmonary hypertension
  - Pulmonary edema
  - Right HF ⟶ ↑ the systemic capillary pressure ⟶ systemic edema.



Types of Heart Dysfunction That Lead To HF

SYSTOLIC DYSFUNCTION

IMPAIRED CONTRACTILITY

THIN/ WEAK HEART MUSCLE

LOW EJECTION FRACTION

S3 GALLOP

SYS-TOL-IC

SYSTOLIC ETIOLOGIES: ISCHEMIC HEART DISEASE, CHRONIC HYPERTENSION, DILATED CARDIOMYOPATHY, AND MYOCARDITIS

SYSTOLIC AND DIASTOLIC DYSFUNCTION CAN APPEAR IN COMBINATION

DIASTOLIC ETIOLOGIES: HYPERTENSION WITH LV HYPERTROPHY, RESTRICTIVE AND HYPERTROPHIC CARDIOMYOPATHIES, FIBROSIS, AMYLOIDOSIS, SARCOIDOSIS, CONSTRICTIVE PERICARDITIS, HEMOCHROMATOSIS, VALVULAR DISEASE, AND AGING

DIASTOLIC DYSFUNCTION

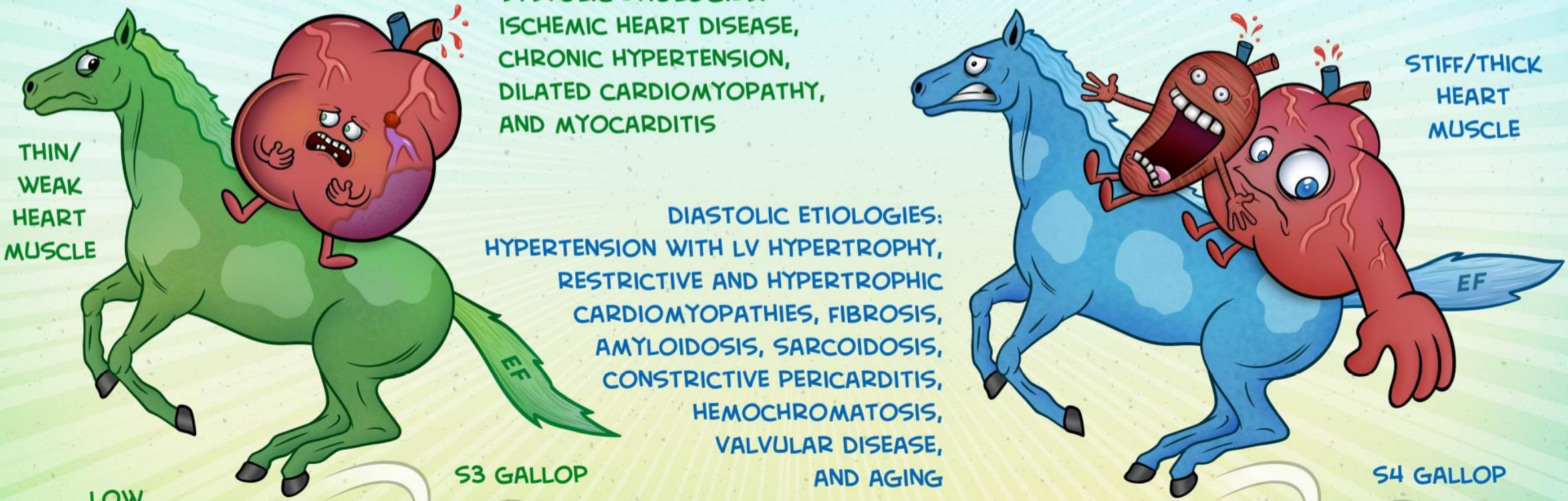
IMPAIRED FILLING/RELAXATION

STIFF/THICK HEART MUSCLE

NORMAL EJECTION FRACTION

S4 GALLOP

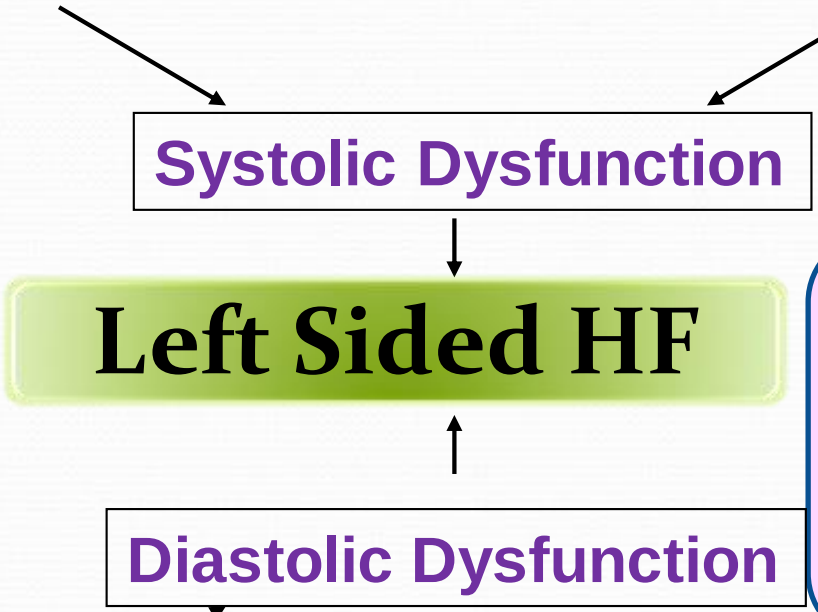
DI-AS-TOL-IC



Causes of Left Sided HF

Impaired Contractility
- Myocardial infarction
- Transient ischemia
- Chronic volume overload
  - MR/AR

Increased Afterload
- AS
- Uncontrolled HTN



- In both types, blood may "back up" in the lungs causing fluid to leak into the lungs (pulmonary edema)
- Fluid may also build up in tissues throughout the body (edema)

Obstruction of LV filling
- MS
- Pericardial constriction or tamponade

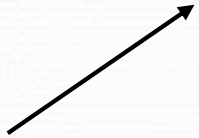
Impaired ventricular relaxation
- Hypertrophic or restrictive cardiomyopathy
- Transient ischemia

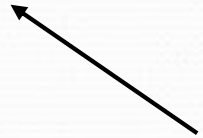
Causes of Right Sided HF

Cardiac Causes

- Usually occurs as a result of left HF
- Pulmonary stenosis
- Right ventricular infarction

Right Sided HF





Pulmonary Vascular Disease

- Pulmonary emobolism
- Pulmonary HTN
- Right ventricular infarction

Pulmonary Parenchymal disease

- COPD
- Interstitial lung disease
- Chronic infections
- Adult respiratory distress syndrome

COR PULMONALE
Right HF due to chronic lung disease

Acute vs. Chronic Heart Failure

- Acute heart failure is a short-term condition (hour/days) due to sudden serious abnormalities of the heart (e.g., massive infarction, arrhythmias, valve rupture; sepsis). [usually left-sided]
- It can be life threatening because the heart does not have time to undergo compensatory adaptations.
- Cardiogenic shock develops following acute failure if the heart became unable to pump enough to even keep tissues alive.

- Chronic heart failure is a long-term condition (months/years).
- It is associated with adaptive responses in the heart, (hypertrophy) which can be deleterious.

Compensatory Mechanisms in CHF

1- Decreased firing of carotid sinus baroreceptor → increased sympathetic stimulation:

→vasoconstriction of arterioles .

→vasoconstriction of veins.

→increased HR and force of contractility.

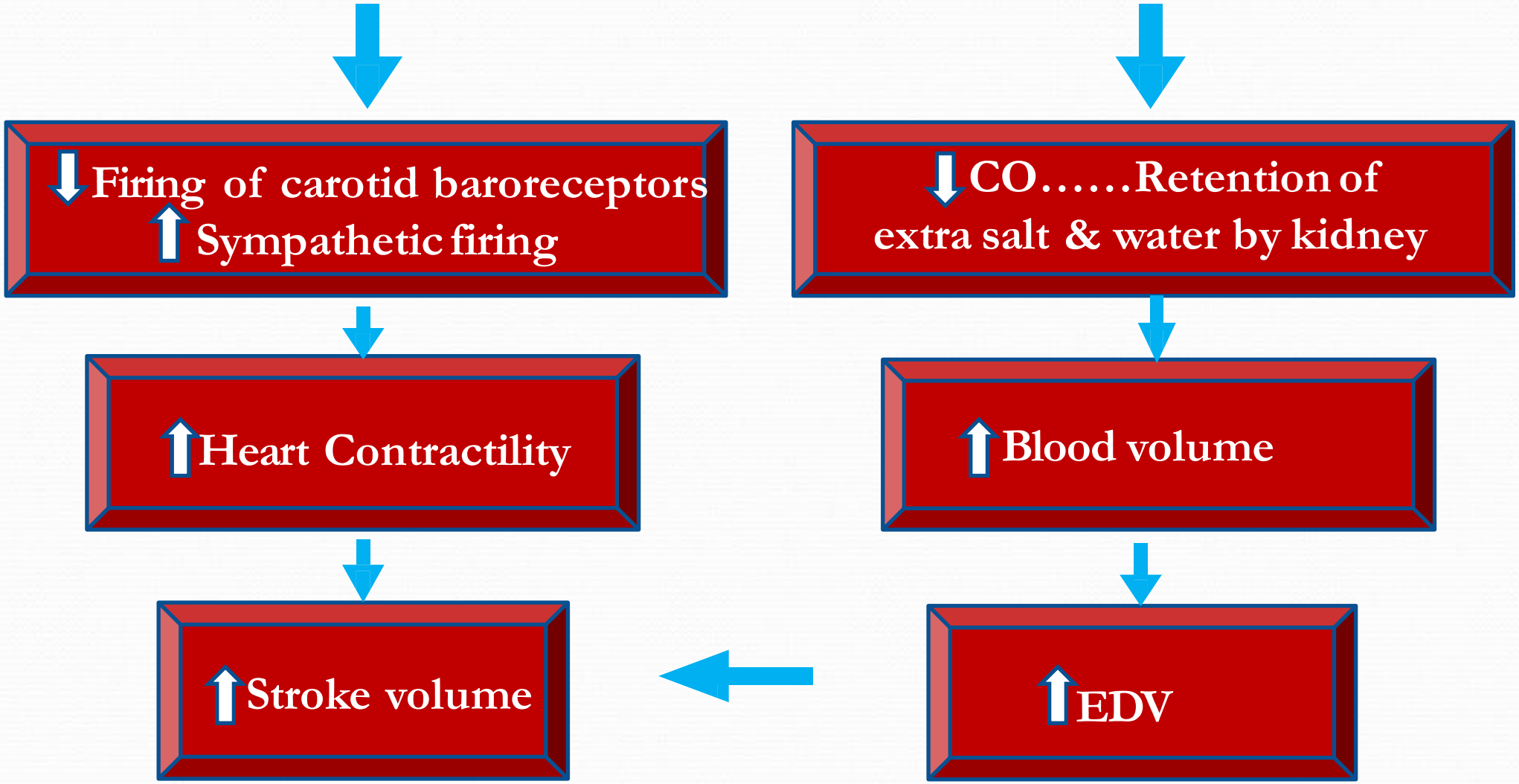
→increased CO and increased BP.

2- Decreased renal perfusion → Activation of renin–angiotensin-aldosterone system → retention of extra salt & water by kidney

3- Decreased effective circulating blood volume → posterior pituitary releases ADH (vasopressin) → increased H_2O reabsorption.

ANP and BNP are major antagonizing agents of the renin– angiotensin-aldosterone system.

Compensatory Mechanisms in Heart Failure



Complications of Progressive Heart Failure :

Factors Contributing to Decompensation

- Prolonged sympathetic activation to the heart: down regulation of the myocardial adrenergic receptors → ↓ the myocardial adrenergic receptors density and sensitivity to catecholamines. Consequently, the inotropic and chronotropic reponses of the heart cannot be elevated in parallel to increased body requirements.
- Vasoconstriction of the arterioles (under enhanced sympathetic activity): This increases resistance, thus the cardiac afterload.
- Hypertrophied heart: → imbalance between the O_2 supply and need → deterioration of the ability to generate force.
- Excessive salt and water retention.
- Over-distended ventricle: Has to consume more energy and generate more wall tension to develop the required ejection pressure (Laplace law).

Clinical Picture of HF

Poor Cardiac Output

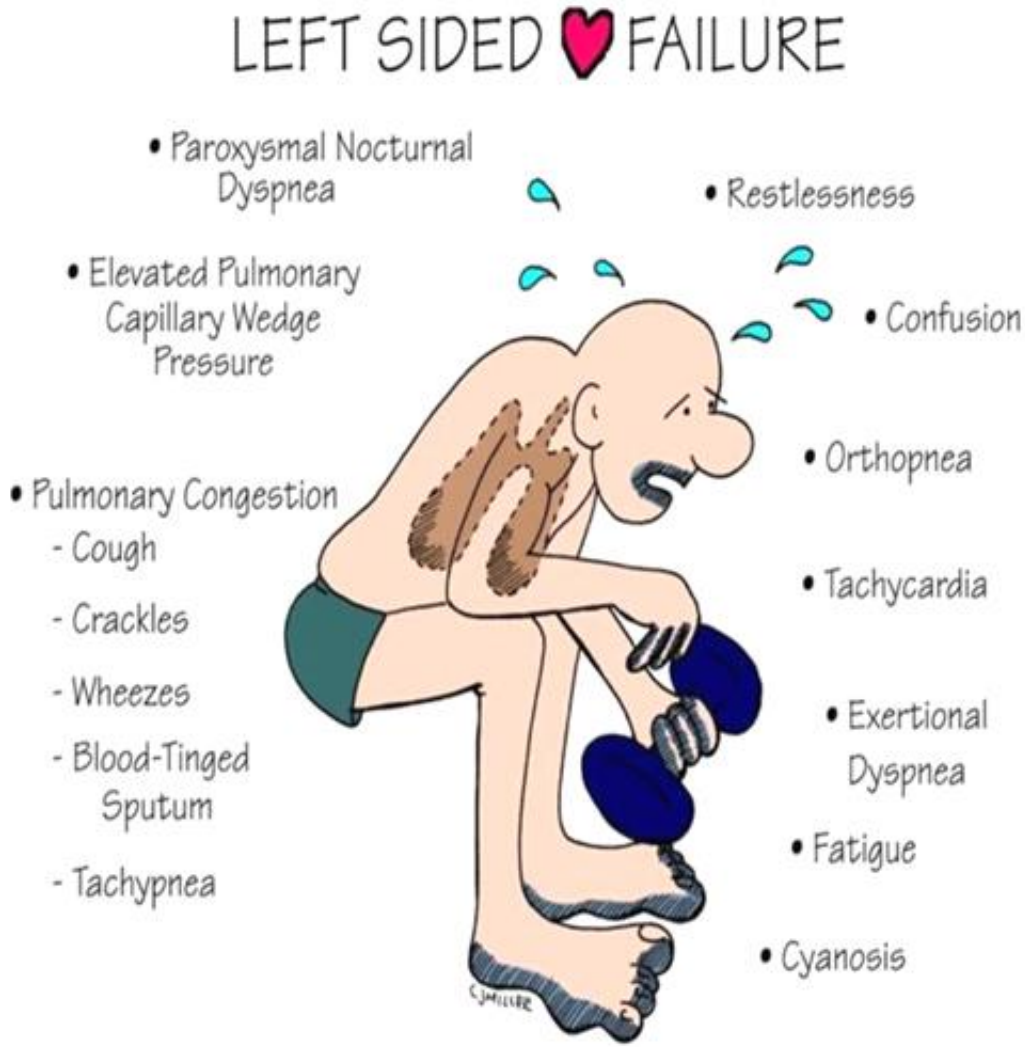
Poor Perfusion

Increased filling pressures

Congestion

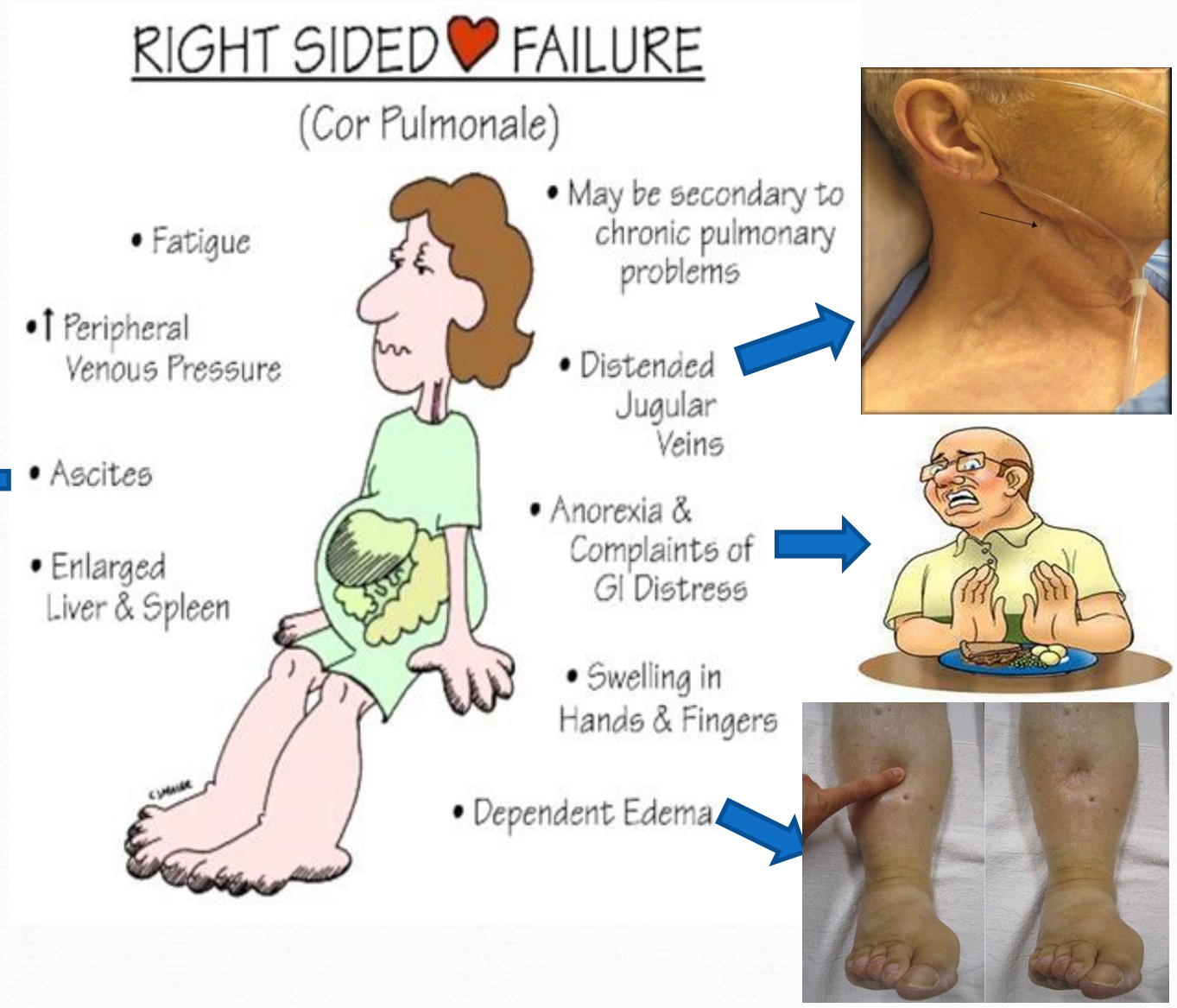
Clinical Picture of Left –Sided Heart Failure

- Tachypnea, shortness of breath (dyspnea).
- Orthopnea: dyspnea that occurs when lying flat, causing the person to have to sleep propped up in bed or sitting in a chair.
- Paroxysmal nocturnal dyspnea: attacks of severe shortness of breath and coughing at night. It usually awakens the person from sleep, and may be quite frightening.
- Cough, rales (crackles) due to pulmonary edema.
- Restlessness, confusion and fatigue.
- Pallor, cyanosis.
- Tachycardia.



Clinical Picture of Right-Sided Heart Failure

- Fatigue.
- Ascites.
- Enlarged liver & spleen.
- Distended jugular veins.
- Anorexia & complaints of GI distress.
- Swelling of hands & Feet.
- Dependent edema.



Comparison Between Clinical Picture of Right & Left-Sided HF

Clinical picture	Left-sided failure	Right-sided failure
Pitting edema (hands & legs)	Mild to moderate	Moderate to sever
Fluid retention	Pulmonary edema (fluid in lungs), and pleural effusion (fluid in the pleural cavity)	Abdomen (ascites)
Organ enlargement	Heart	Liver. Mild jaundice may be present
Neck veins	Mild to moderate elevation in JVP	Sever elevation in JVP. Neck veins are visibly distended
Shortness of breath	Prominent dyspnea, paroxysmal nocturnal dyspnea, and orthopnea	Dyspnea is present but not as prominent
GIT symptoms: Loss of appetite, bloating, constipation.	Present but not as prominent as in right-sided failure	Significantly more prominent than in left-sided failure

How Heart Failure Is Diagnosed

- Medical history is taken to reveal symptoms.
- Physical examination.
- Tests
  - Chest X-ray.
  - Electrical tracing of heart (ECG).
  - Ultrasound of heart (Echocardiogram or "Echo").
  - X-ray of the inside of blood vessels (Angiogram).

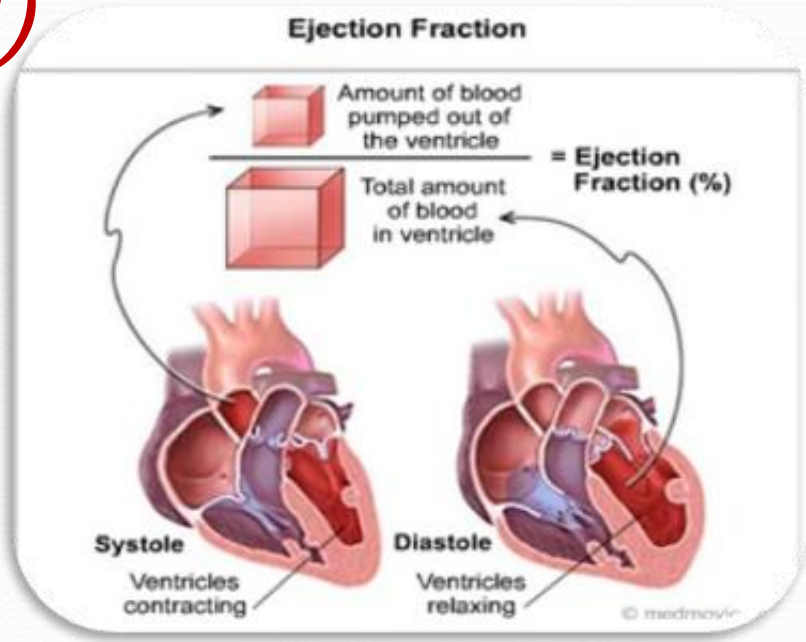
A Key Indicator for Diagnosing Heart Failure

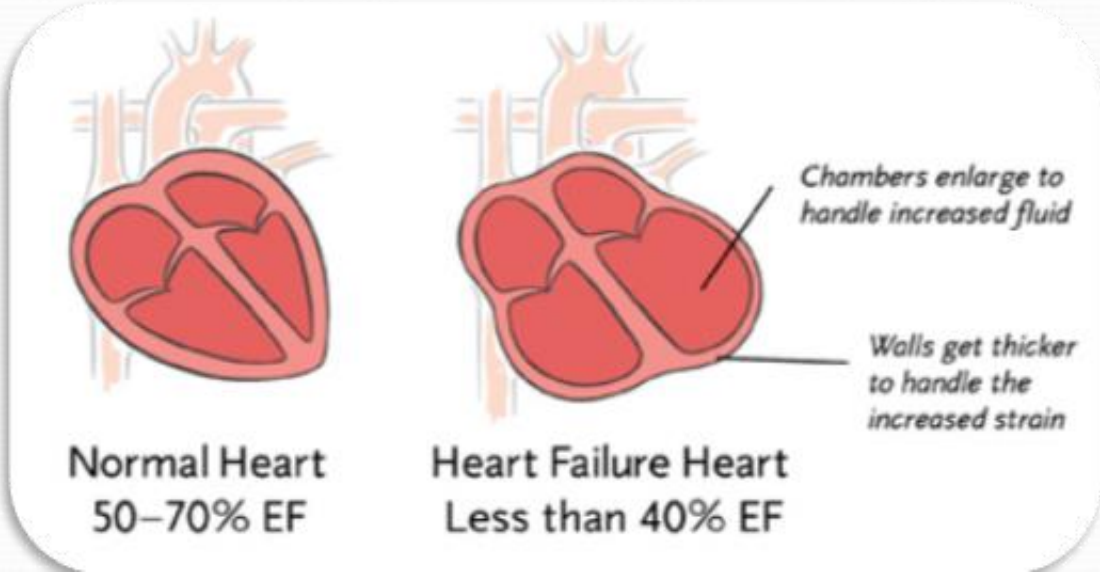
Ejection Fraction (EF)

- Ejection Fraction (EF) is the percentage of blood that is pumped out of the ventricle during each beat
- ***Fractional Shortening….***

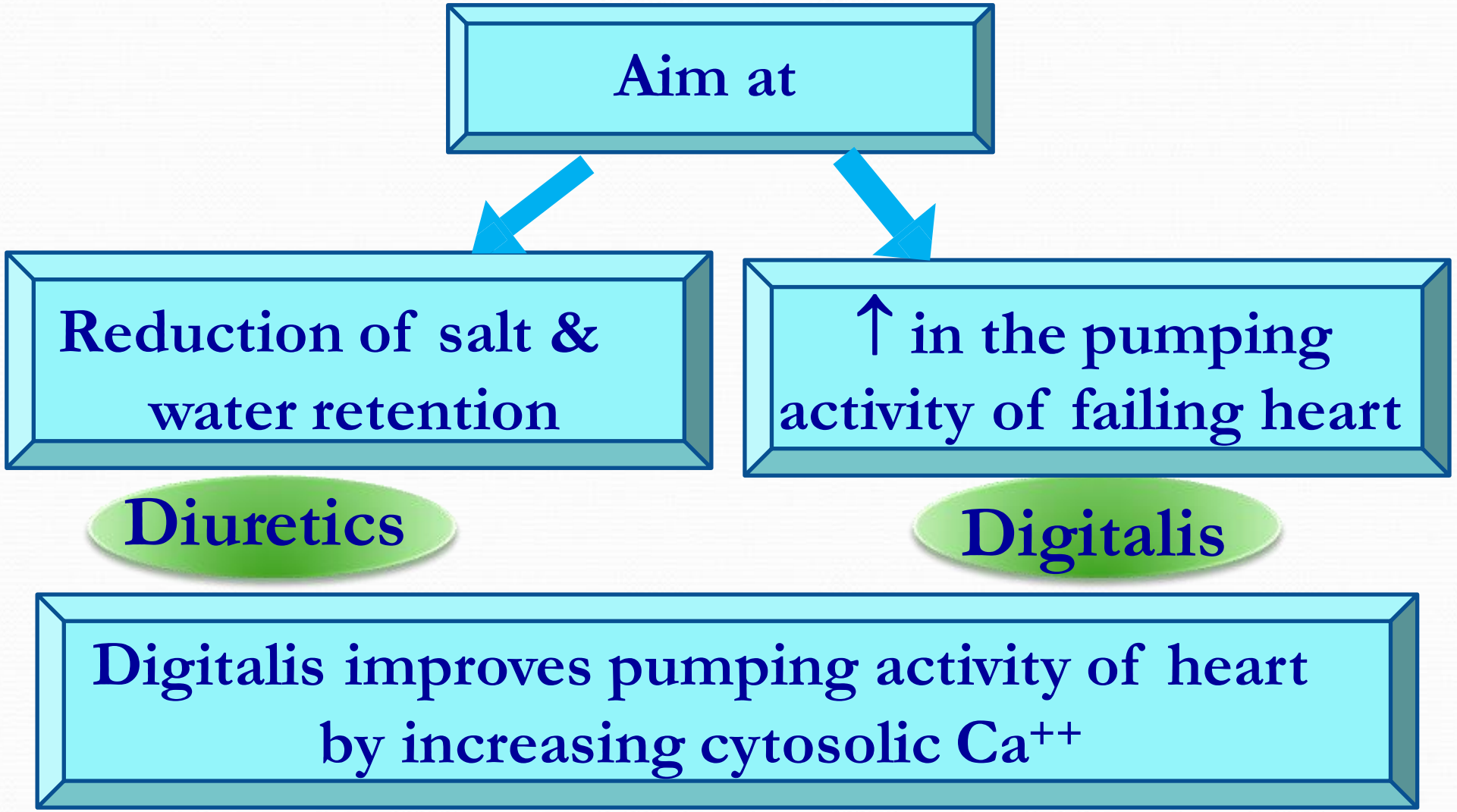
  This is one of the most basic measures in adult functional echocardiography.

  It simply looks at the degree of shortening of the left ventricular diameter between end-diastole and end-systole.

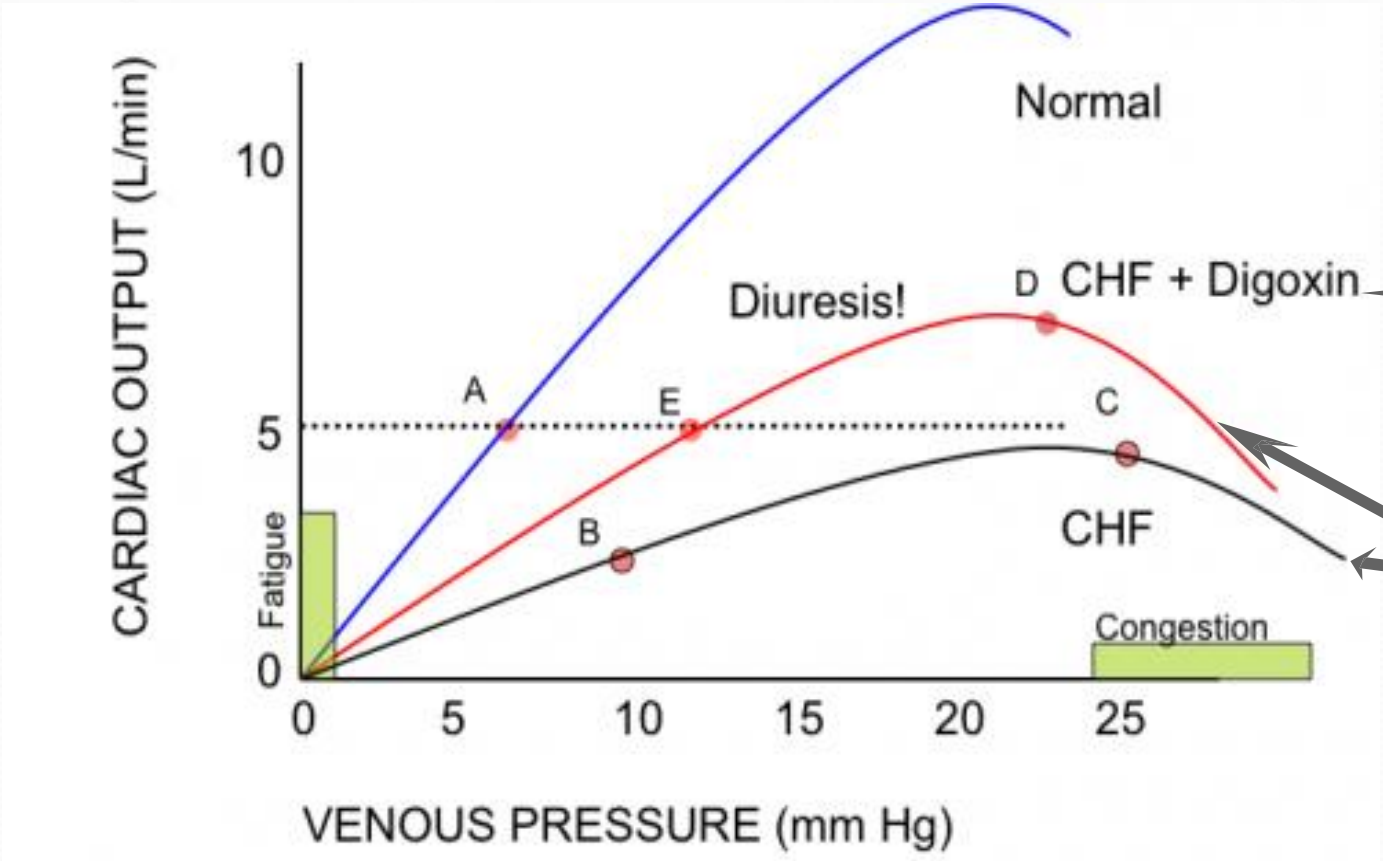




Treatment of Cardiac Failure



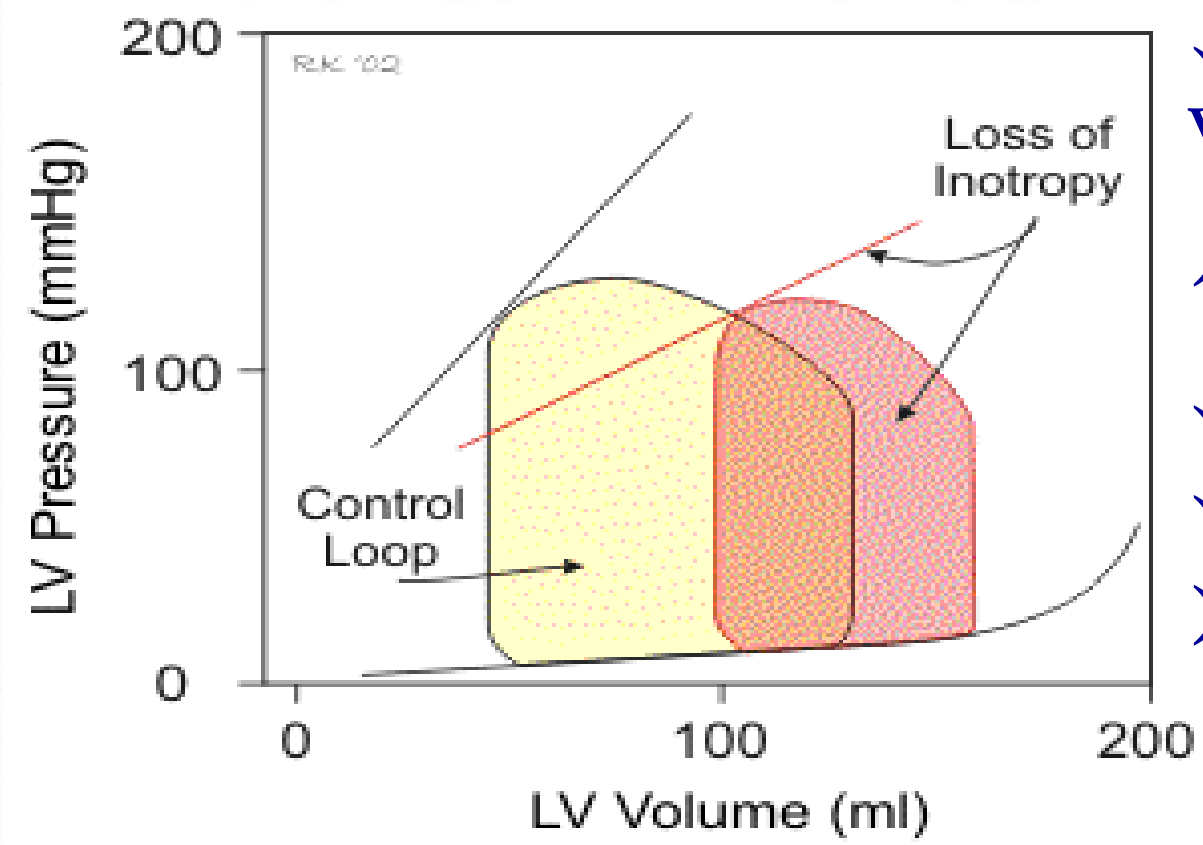
Effect of Congestive Heart Failure & Digoxin on Frank-Starling Curve



EFFECT?

Changes in contractility

Effect of Left Ventricular Systolic Failure on Left Ventricular Pressure Volume Loop.



↓ slope of End-systolic pressure-volume relationship (ESPVR) i.e.↑ESV

Compensatory rise in preload i.e.

↑ EDV

↓ SV

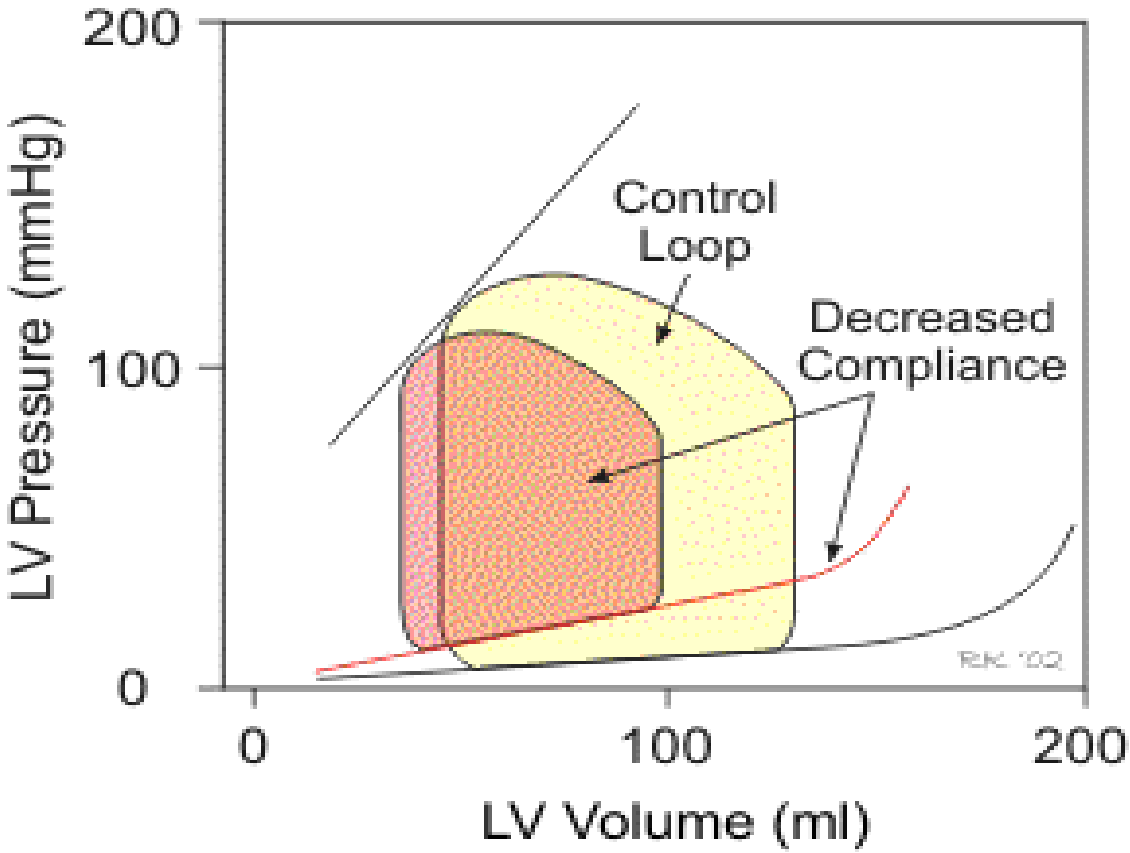
↓ EF

↓ Work

↑ EDP

Heart rate is unchanged.

Effect of Left Ventricular Diastolic Failure on Left Ventricular Pressure Volume Loop.



↓ Ventricular compliance/relaxation (lusitropy).
↓ EDV
↓ SV
↓ or =EF
↓ Work
↑ EDP

Heart rate, inotropy and systemic vascular resistance are unchanged.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