Heart Failure

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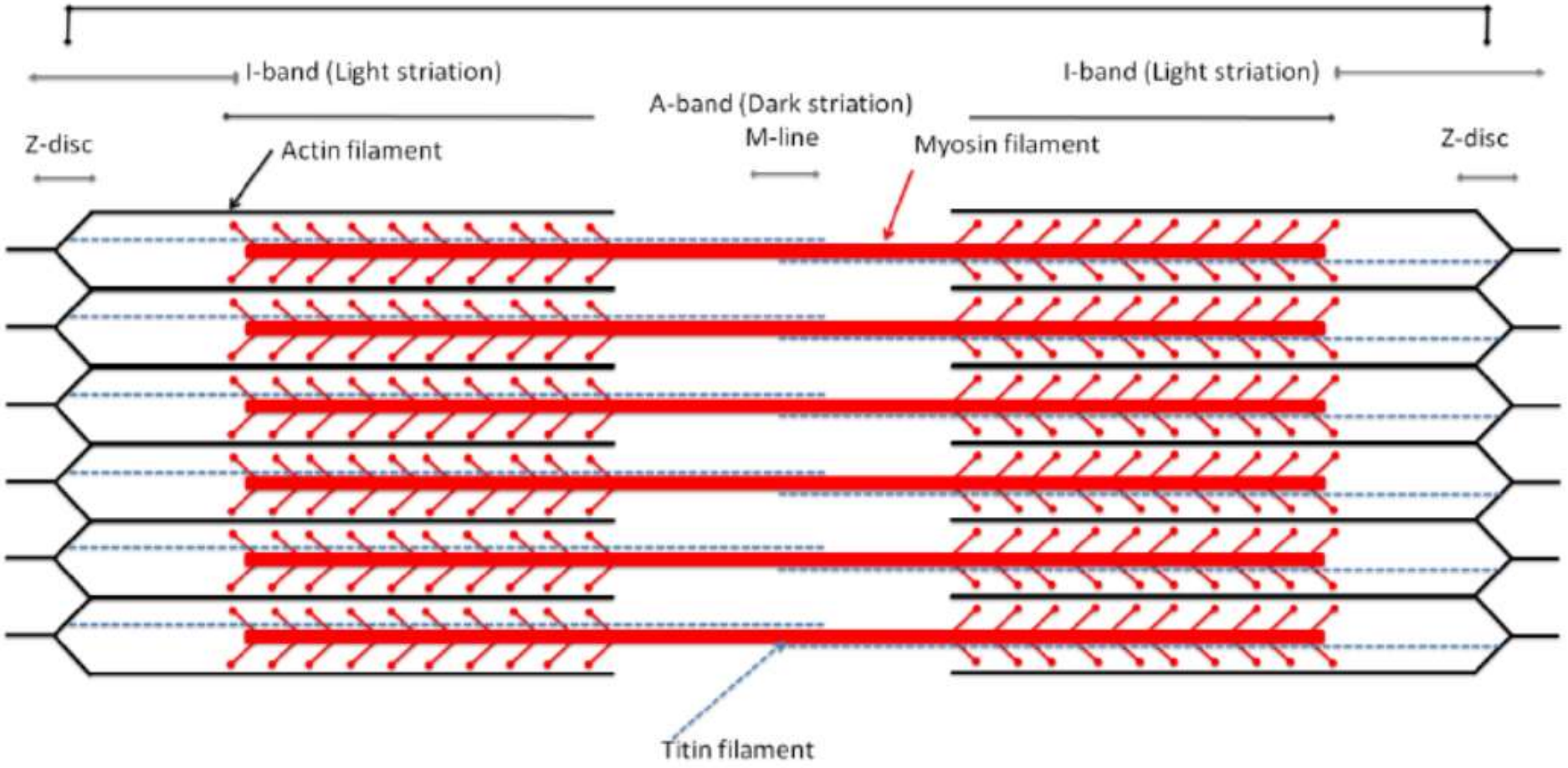
Sarcomere


I-band (Light striation)
A-band (Dark striation)
I-band (Light striation)
Z-disc
Actin filament
M-line
Myosin filament
Z-disc
Titin filament

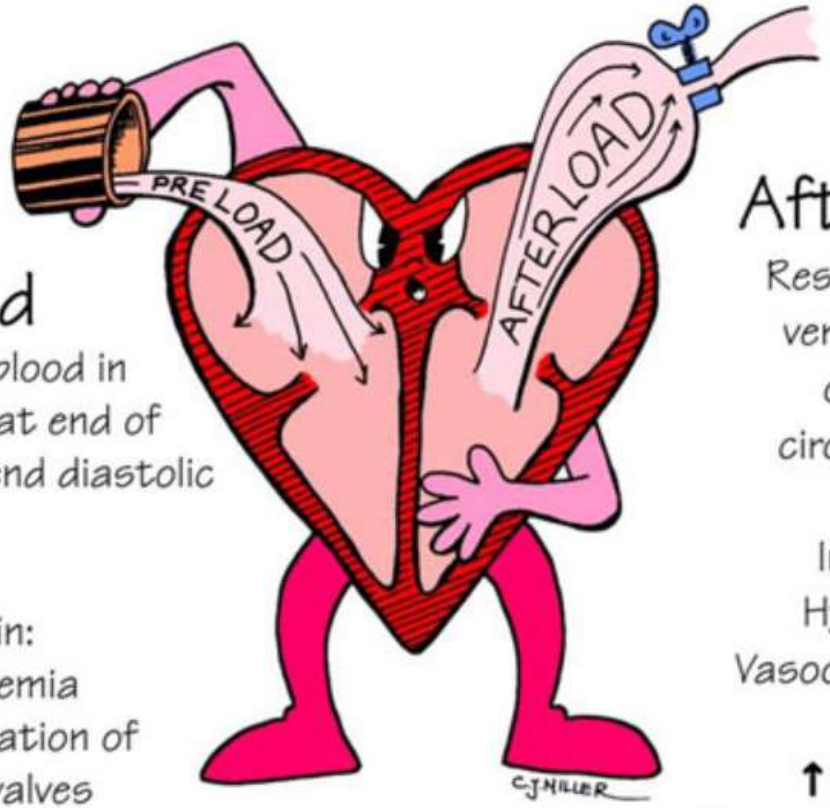
Factors Affecting Cardiac Performance

Preload

(fiber length, LV filling pressure or volume)

Afterload

PRELOAD AND AFTERLOAD



Preload

Volume of blood in ventricles at end of diastole (end diastolic pressure)

Increased in:

- Hypervolemia
- Regurgitation of cardiac valves
- Heart Failure

Afterload

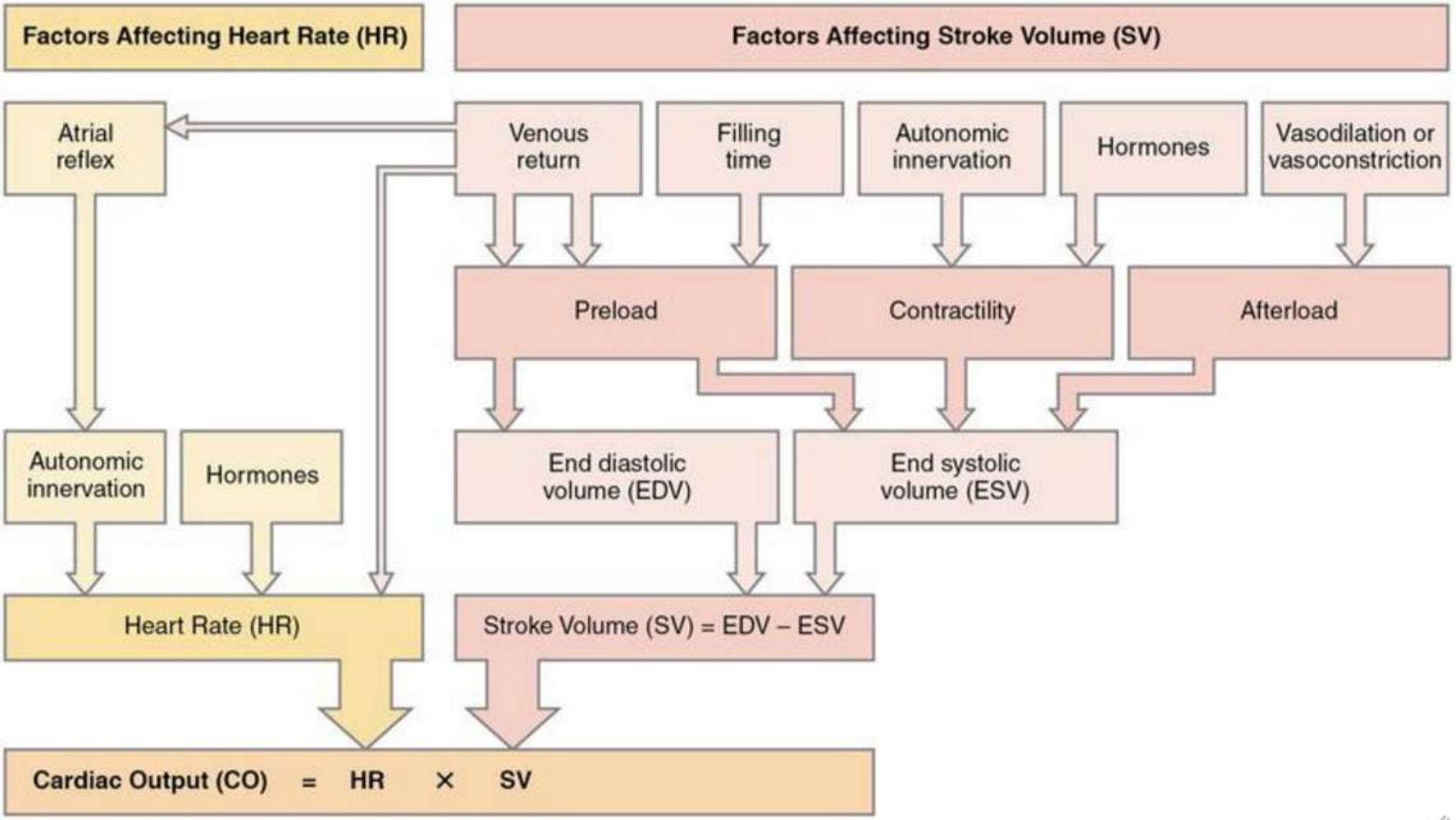
Resistance left ventricle must overcome to circulate blood

Increased in:

- Hypertension
- Vasoconstriction

↑ Afterload = ↑ Cardiac workload

STROKE VOLUME AND CARDIAC OUTPUT

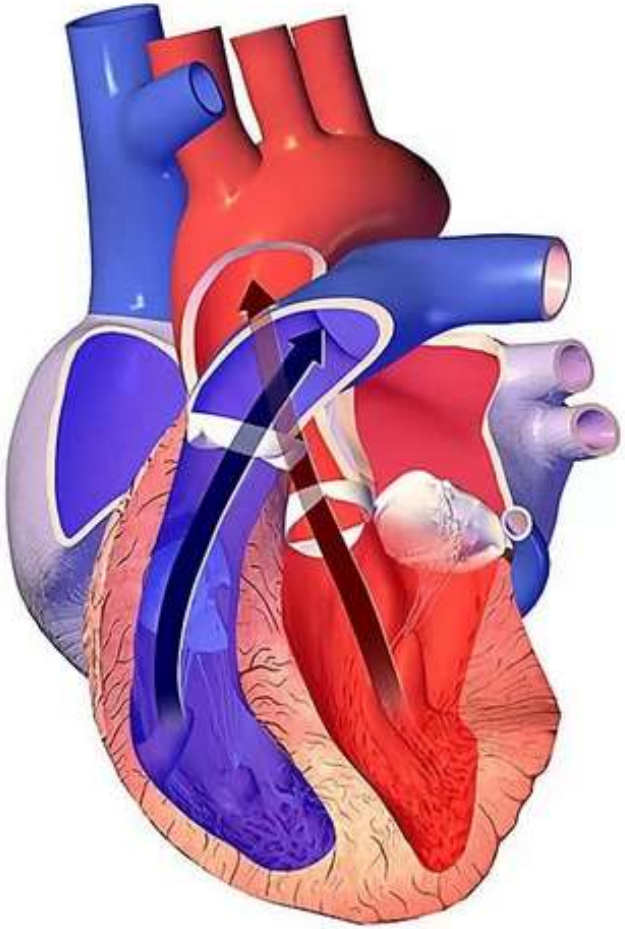


CARDIAC OUTPUT

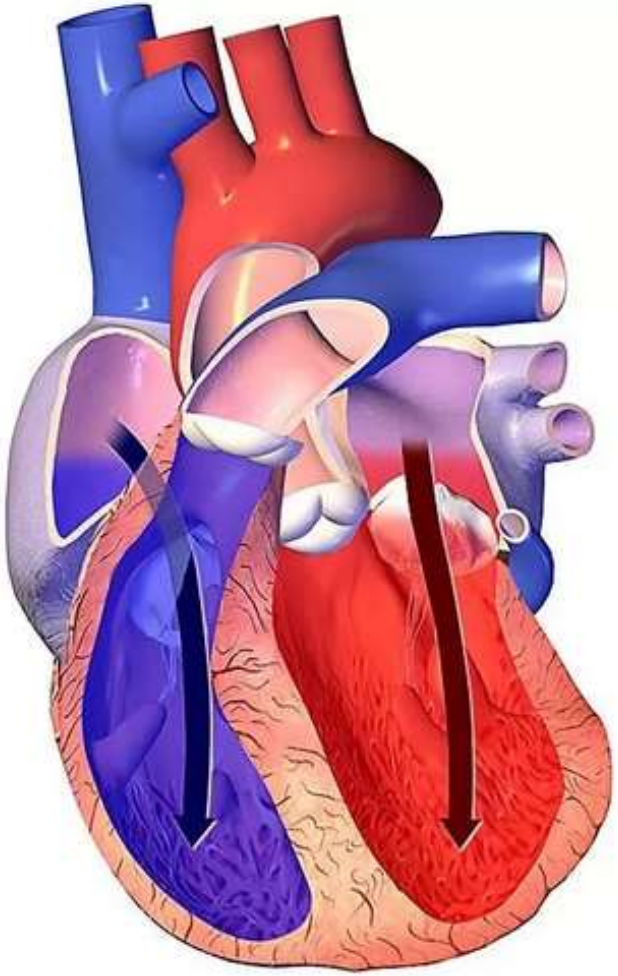
CO = HR X Stroke Volume

Cardiac Output — Heart Rate

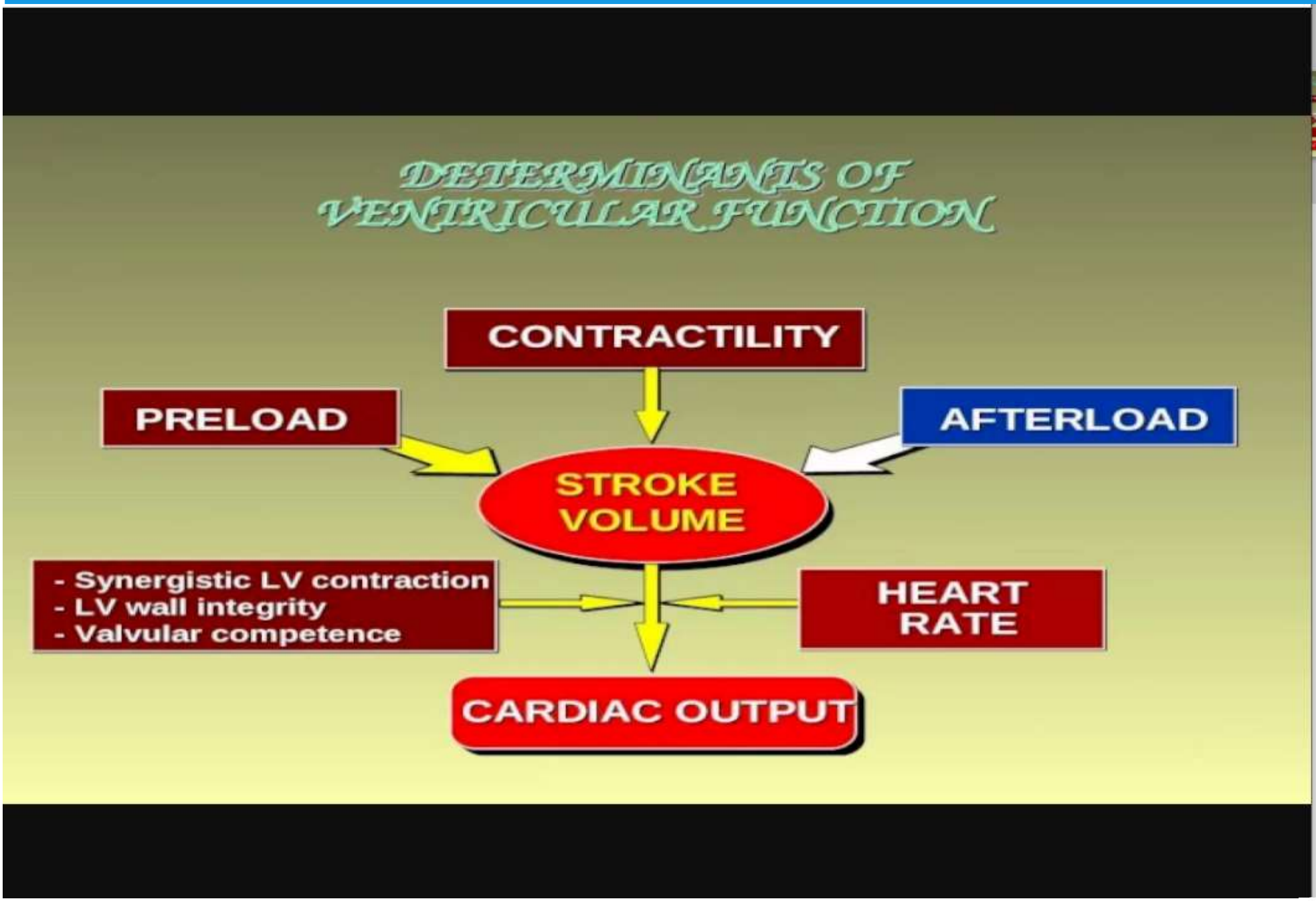
	Factors Affecting Stroke Volume (SV)		
	Preload	**Contractility**	**Afterload**
Raised due to:	• fast filling time • increased venous return **Increases end diastolic volume,** **Increases stroke volume**	• sympathetic stimulation • epinephrine and norepinephrine • high intracellular calcium ions • high blood calcium level • thyroid hormones • glucagon **Decreases end systolic volume,** **Increases stroke volume**	• increased vascular restistance • semilunar valve damage **Increases end systolic volume** **Decreases stroke volume**
Lowered due to:	• decreased thyroid hormones • decreased calcium ions • high or low potassium ions • high or low sodium • low body temperature • hypoxia • abnormal pH balance • drugs (i.e., calcium channel blockers) **Decreases end diastolic volume,** **Decreases stroke volume**	• parasympathetic stimulation • acetylcholine • hypoxia • hyperkalemia **Increases end systolic volume** **Decreases stroke volume**	• decreased vascular resistance **Decreases end systolic volume** **Increases stroke volume**



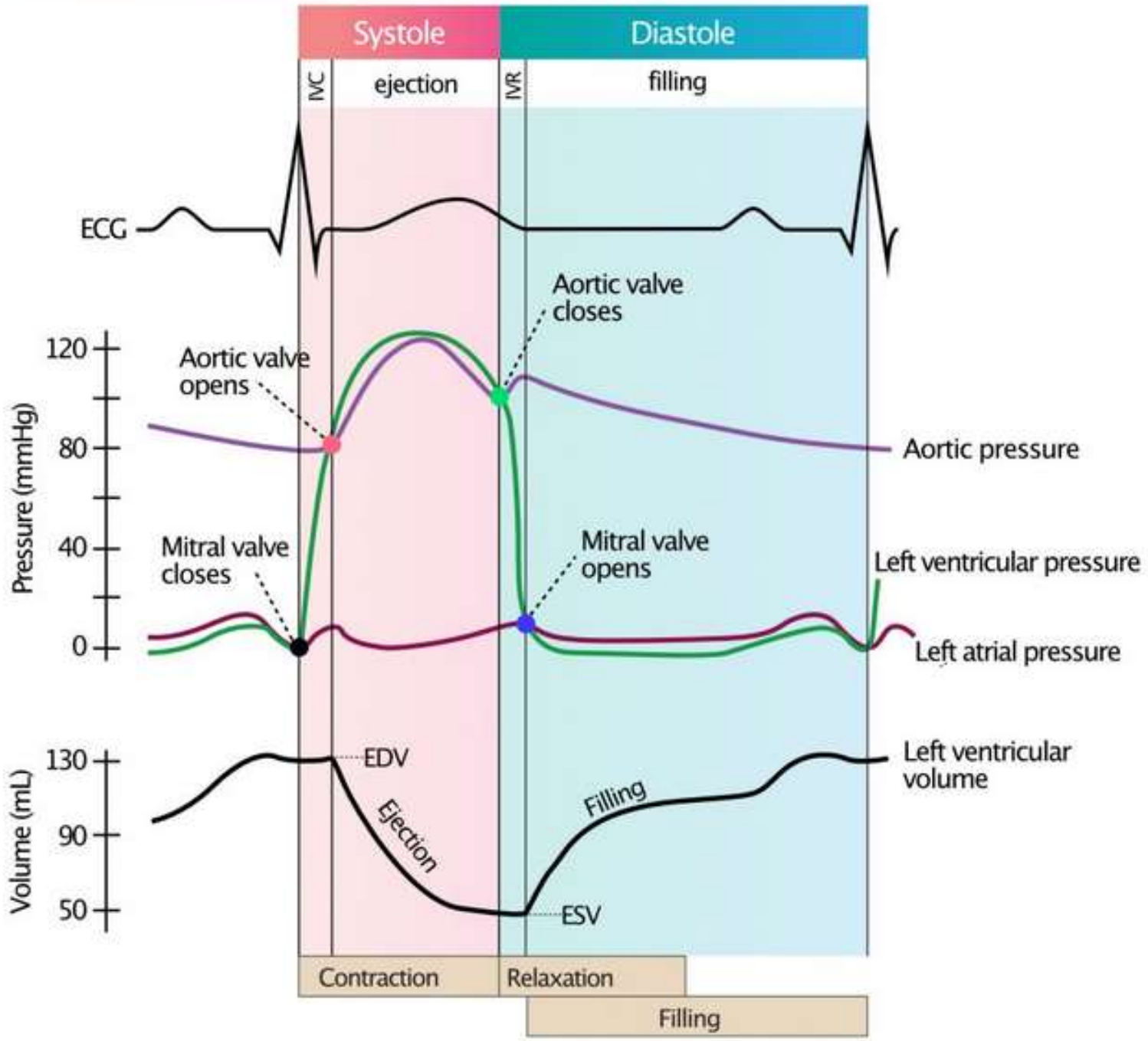
Systole
(pumping)

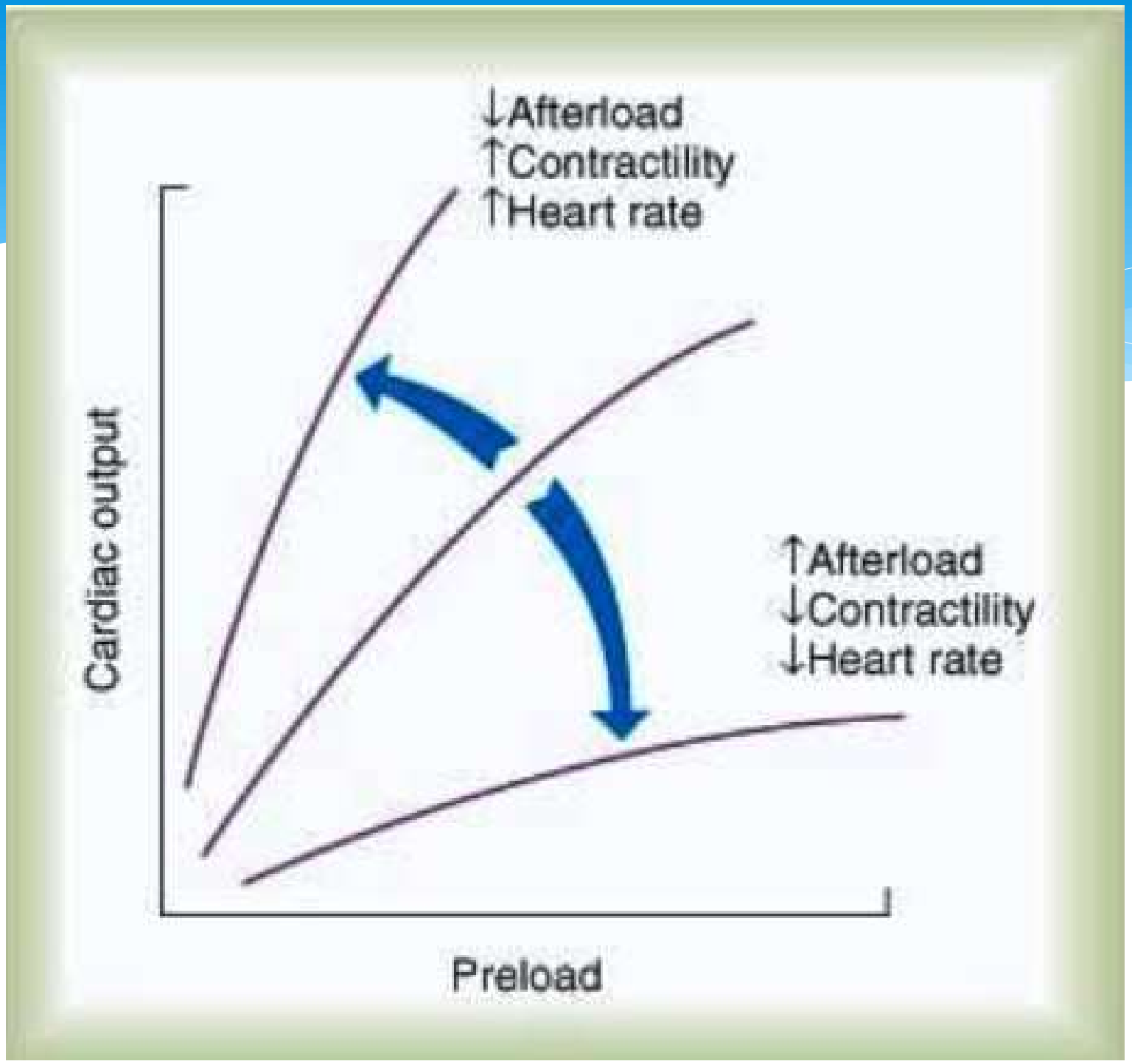


Diastole
(filling)

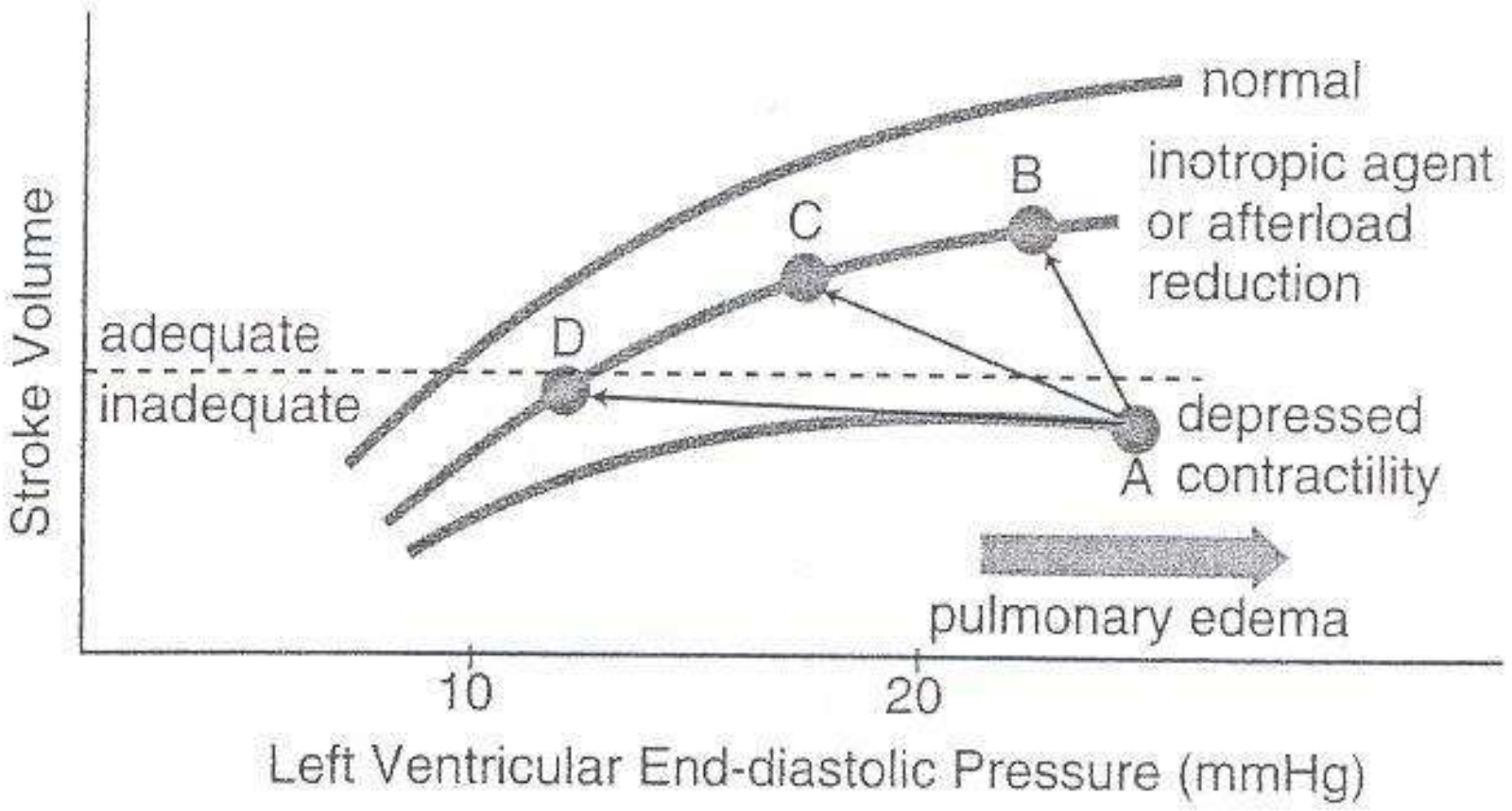

DETERMINANTS OF VENTRICULAR FUNCTION
CONTRACTILITY
PRELOAD
AFTERLOAD
STROKE VOLUME
- Synergistic LV contraction
- LV wall integrity
- Valvular competence
HEART RATE
CARDIAC OUTPUT

Relationship between pressure, volume and ECG




↓Afterload
↑Contractility
↑Heart rate
↑Afterload
↓Contractility
↓Heart rate
Cardiac output
Preload

Factors Affecting Cardiac Performance



Factors Affecting Cardiac Performance

Preload (Left Ventricular Diastolic Volume)

- Total Blood Volume

-Venous tone (sympathetic tone)

- Body position

-Intrathoracic and intrapericardial pressure

-Atrial contraction

-Pumping action of skeletal muscle

Factors Affecting Cardiac Performance

Afterload

(Impedance Against Witch the Left Ventricle Must Eject Blood)

-Peripheral vascular resistance

-left ventricular volume

- Physical characteristics of the arterial tree

(elasticity of vessels or presence of outflow obstruction)

Factors Affecting Cardiac Performance

Contractility

- sympathetic

-catecholamines

- inotropic (digitalis, Calcium, ..)

-Increased Heart Rate or postextrasystolic beat

-Anoxia , Acidosis

-loss of myocardium

-Pharmacologic depression

-Intrinsic depression

Factors Affecting Cardiac Performance

Heart Rate

- Autonomic nervous system
- Temperature, Metabolic rate

Heart Failure

Heart is unable to pump blood

- *Myocardial contractility*
- *Abnormal loading condition*
  - *Afterload(Pressure overload)*
  - *Preload (Volume overload)*

Etiology Of Heart Failure

- *Fetus*
- *Premature Neonate*
- *Full- Term Neonate*
- *Infant – Toddler*
- *Child – Adolescent*

Etiology of Heart Failure by Age Group

FETUS

* **Severe anemia** (hemolysis, fetal-maternal transfusion, hypoplastic anemia)
* **Supraventricular tachycardia**
* **Ventricular tachycardia**
* **Complete heart block**
* **Atrioventricular valve insufficiency**
* **High-output cardiac failure** (arteriovenous malformation, teratoma)

Etiology of Heart Failure by Age Group

PREMATURE NEONATE

* Fluid overload
* PDA
* VSD
* Cor pulmonale (BPD)

Etiology of Heart Failure by Age Group

FULL-TERM NEONATE

* Asphyxial cardiomyopathy
* Arteriovenous malformation (vein of Galen, hepatic)
* Left-sided obstructive lesions (coarctation of aorta, hypoplastic left heart, critical aortic stenosis)
* Transposition of great arteries
* Large mixing cardiac defects (single ventricle, truncus arteriosus)
* Viral myocarditis
* Anemia
* Supraventricular tachycardia
* Complete heart block

Etiology of Heart Failure by Age Group

INFANT/TODDLER

* Left-to-right cardiac shunts (VSD)
* Hemangioma (arteriovenous malformation)
* Anomalous left coronary artery
* Metabolic cardiomyopathy
* Acute hypertension (hemolytic uremic syndrome)
* Supraventricular tachycardia
* Kawasaki disease
* Postoperative repair of congenital heart disease

Etiology of Heart Failure by Age Group

* **CHILD/ADOLESCENT**

* Rheumatic fever
* Acute hypertension (glomerulonephritis)
* Viral myocarditis
* Thyrotoxicosis
* Hemochromatosis/hemosiderosis
* Cancer therapy (radiation, doxorubicin)
* Sickle cell anemia
* Endocarditis
* Cor pulmonale (cystic fibrosis)
* Arrhythmias
* Chronic upper airway obstruction (cor pulmonale)
* Unrepaired or palliated congenital heart disease
* Cardiomyopathy

Clinical Manifestations

Infants

-Poor feeding
-Failure to thrive
-Tachypnea
-Diaphoresis with feeding

Older child

- Shortness of breath
- Easy fatigability
- Edema

Clinical Manifestations

-Pulmonary congestion

-Systemic venous congestion

-Tachycardia

-Gallop rhythm

-Thread pulses

-Tachypnea

-Orthopnea

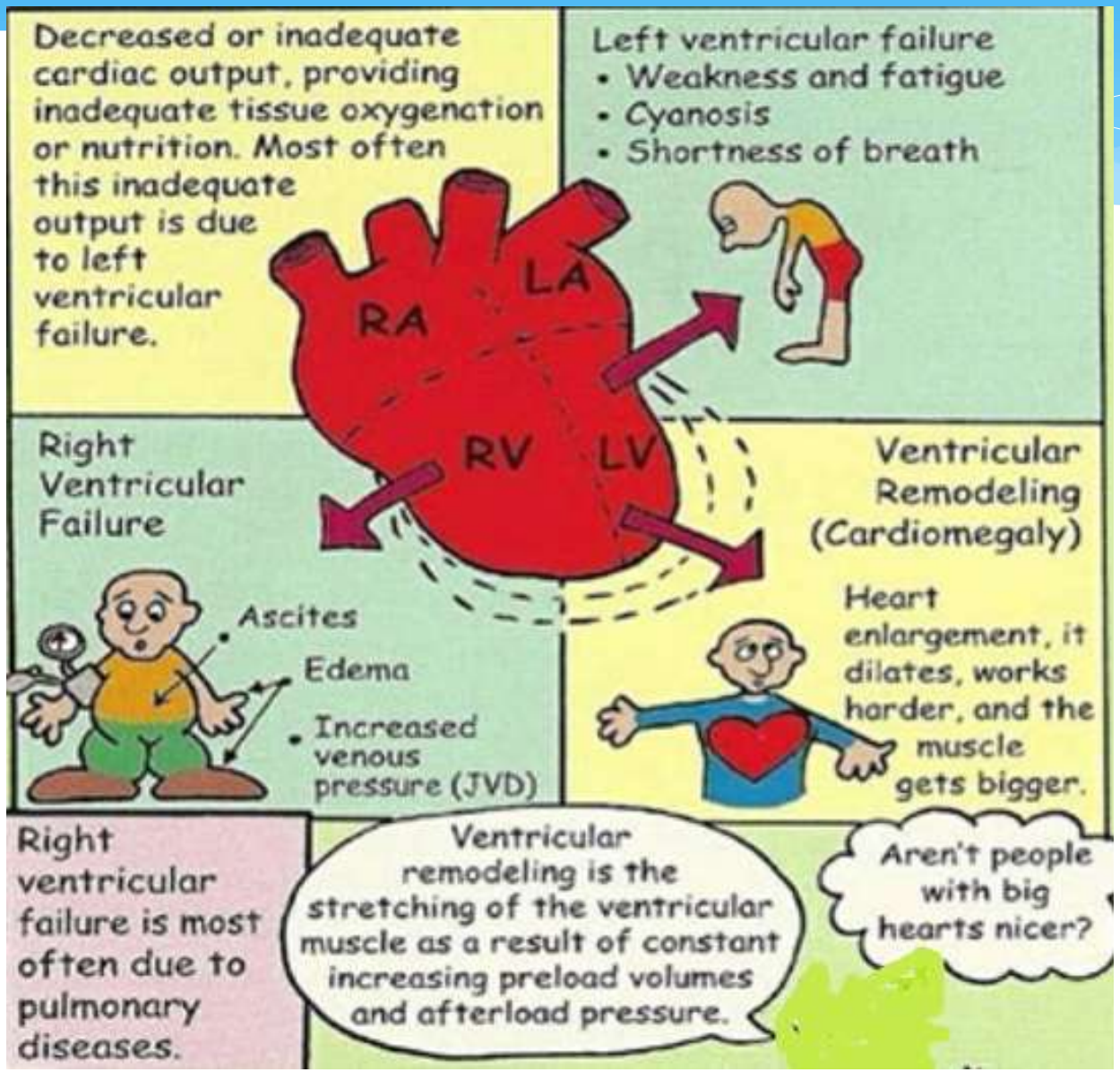
-Wheezing

-Pulmonary Edema

-Hepatomegaly

-Edema

-Distended neck vein


Decreased or inadequate cardiac output, providing inadequate tissue oxygenation or nutrition. Most often this inadequate output is due to left ventricular failure.
Left ventricular failure
• Weakness and fatigue
• Cyanosis
• Shortness of breath
RA
LA
RV
LV
Right Ventricular Failure
Ascites
Edema
Increased venous pressure (JVD)
Ventricular Remodeling (Cardiomegaly)
Heart enlargement, it dilates, works harder, and the muscle gets bigger.
Right ventricular failure is most often due to pulmonary diseases.
Ventricular remodeling is the stretching of the ventricular muscle as a result of constant increasing preload volumes and afterload pressure.
Aren't people with big hearts nicer?

Imaging studies

-CXR

-Echocardiography

Treatment

-General Care

-Diuretics

-Inotropic Agents

-Afterload reduction

-Other

Treatment

GENERAL CARE

Rest

Reduces cardiac output

Oxygen

Improves oxygenation in the presence of pulmonary edema

Sodium, fluid restrictions

Decreases vascular congestion; decreases preload

Treatment

Diuretics

Furosemide

- Salt excretion at ascending loop of Henle;
- reduces preload;
- afterload reduces with control of hypertension
- may also cause venodilation

Combination of distal tubule and loop diuretics

- Greater sodium excretion

Treatment

Inotropic Agents

Digitalis

Inhibits membrane Na+, K+-ATPase and increases intracellular Ca ٢+, improves cardiac contractility, increases myocardial oxygen consumption

Dopamine

Releases myocardial norepinephrine plus a direct effect on β-receptor, may increase systemic blood pressure; at low infusion

rates, dilates renal artery, facilitating diuresis

Dobutamine

β ١-Receptor agent; often combined with dopamine

Milrinone

Phosphodiesterase ٣ inhibitor with positive inotropic properties and decreases vascular resistance/afterload

-Carvedilol

β-Blocking agent

Treatment

Afterload reduction

Hydralazine

Arteriolar vasodilator

Nitroprusside

Arterial and venous relaxation; venodilation reduces preload

Captopril/enalapril

Inhibition of ACE; reduces angiotensin II production

Treatment

Other

-Mechanical counterpulsation

Improves coronary flow, afterload

-Transplantation

Removes diseased heart

-Extracorporeal membrane oxygenation

Bypasses heart


Thanks for your attention