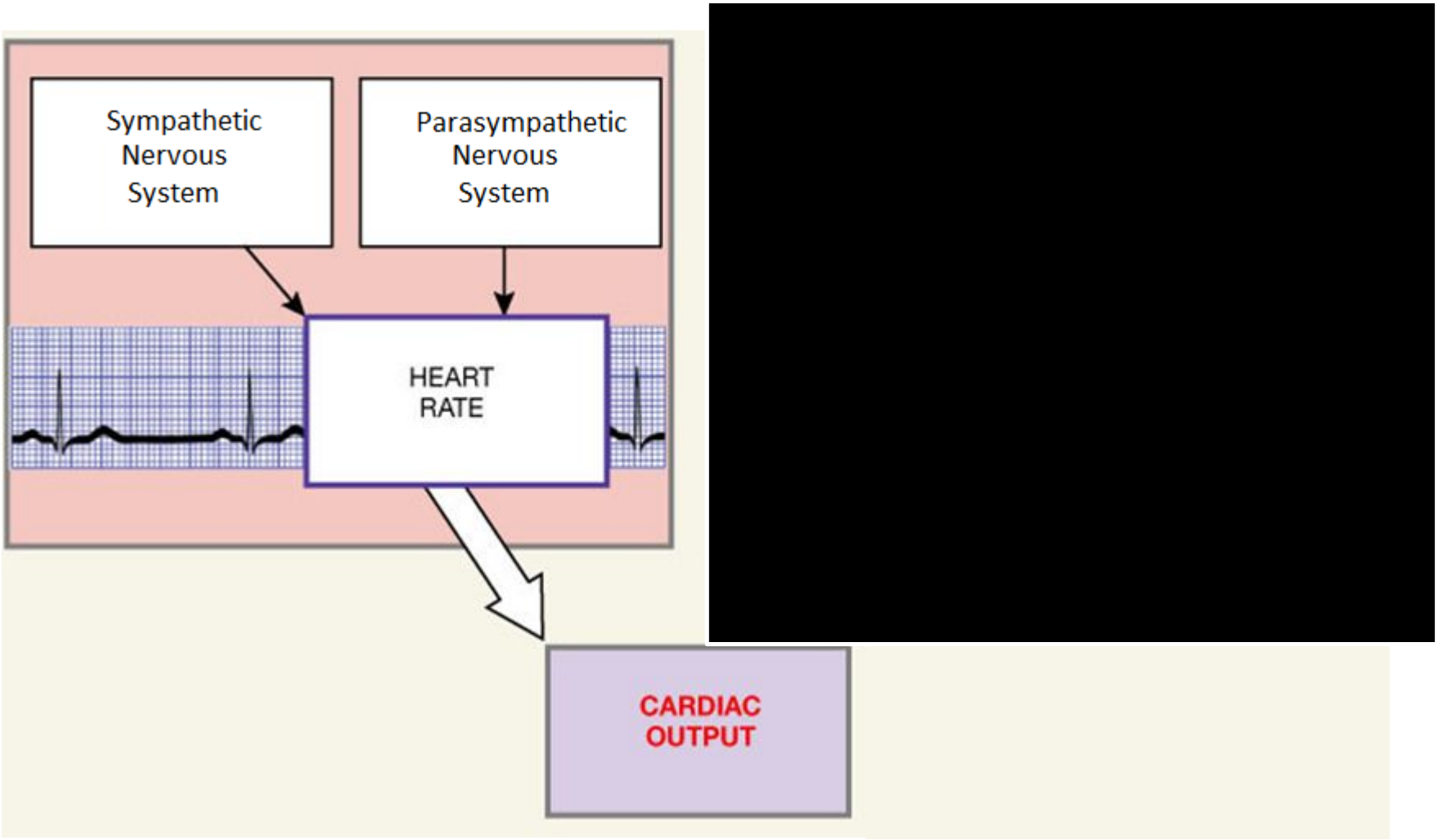
Cardiac Reserve is the difference between cardiac output at rest and maximum volume of blood that the heart is capable of pumping per minute.

FACTORS AFFECTING CARDIAC OUTPUT



CHRONOTROPISM

refers to changes in the heart rate.

Positive And Negative Chronotropic Effect

The heart can only pump what it gets

Factors that regulate *SV*:

- Length of diastole
- Venous return (preload)
- Contractility of the myocardium
- Afterload
- Heart rate

The effect of increased HR is limited by its effect on the length of diastole.

Diastole is the period in which relaxation of the myocardium and ventricular filling take place.

As HR increases, the length of cardiac cycle and therefore length of diastole, time for filling decrease. At very high heart rate, this may result in a decrease in ventricular filling, EDV and a decrease in SV so CO.

Venous return

The volume of blood returned to the right atrium per minute

At constant HR, an increase in venous return, or the rate of blood flow into the heart, will increase ventricular filling, EDV, SV and CO.

As much blood enters, heart contracts more forcefully.

Ventricular filling is increased, this increased volume of blood stretches the walls of these chambers and as a result, the ventricles contract more forcefully. The stronger contraction results in a larger SV.

Contractiliy increases as the amount of calcium available for contraction increases.

Contractility determines EF which is the ratio of the volume of blood ejected from LV per beat to the volume of blood in LV at the end of diastole (EDV)

Afterload is the pressure in the artery leading from the ventricle.

When the ventricle contracts, it must develop a pressure greater than arterial pressure in order to open semilunar valve and eject blood.

Blood Vessel Structure

Blood vessels vary in diameter and wall thickness.

Capillaries are thin enough to allow for diffusion and narrow to restrict RBC to flow in single file

Veins have a larger diameter and thinner walls than arteries.

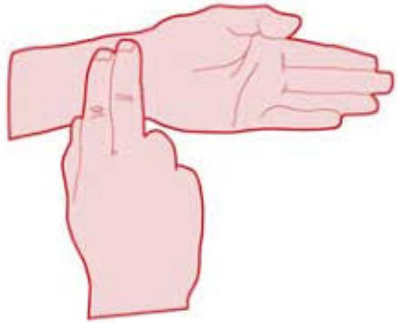
Elastic Recoil in Arteries

By sustaining the driving pressure for blood flow during ventricular relaxation, the arteries keep blood flowing continuously through the blood vessels.

Flow α ΔP/R

Pressure waves created by ventricular contraction

BP is highest in the arteries and decreases continuously



Pulse is the rapid increase occurs when LV pushes blood into the aorta.

Systolic pressure – diastolic pressure = pulse pressure

(strength of the pressure wave)

Low pressure blood in veins blow the heart must flow ‘uphill’ or against gravity to return to the heart.

Pressure throughout the Systemic Circulation

Blood pressure is highest in the arteries and decreases continuously as it flows through the circulatory system.

Systolic pressure is exerted on vessel walls when the heart contracts

Diastolic pressure is pressure during heart relaxation.

Pulse pressure measures strength of pressure wave *systolic P – diastolic P*

Mean arterial pressure measures driving pressure *diastole P + 1/3 pulse pressure.*

Pressure falls over distance as energy is lost because of friction. In circulation the further away the blood is from the heart the lower the pressure. Pressure is lower is veins than in arteries

HYPOTENSION

Blood flow and oxygen supply to the brain are impaired.

HYPERTENSION

High pressure on the walls may cause weakened areas to rupture and bleed.

Mean arterial pressure is a function of cardiac output.

Blood flow into the aorta is equal to the cardiac output of the left ventricle.

Blood flow out of the arteries is influenced by peripheral resistance, the resistance to flow in arterioles.

MAP is proportional to CO times resistance.

If CO increases, heart pumps more blood into the arteries per unit time. Flow into is greater than flow out, blood volume increases, BP increases.

OR if PR increases, flow out decreases, blood accumulates BP increases.

- %60 of blood volume at rest is in systemic veins.

Function as a volume reservoir
Blood is diverted if needed.

- %15 of blood volume is in arteries, arterioles

If BP falls, sympathetic activity constricts veins, decreasing their holding capacity, venous return sends blood to the heart, which pumps all blood received to the circulation, BP increases.

Blood Pressure

Blood pressure control involves both the cardiovascular system and the renal system

Increase or decrease in blood volume is compensated by CV and kidney changes

Flow through the body is equal to the CO but flow to individual tissues can be altered by selectively changing resistance. The distribution of systemic blood varies according to the metabolic needs of organs.
E.G skeletal muscle receives %20 at rest, during exercise as much as %85.
All arterioles receive blood at the same time. Total blood flow is always equal to CO. Flow in branching system depends on resistance.Higher resistance, lower flow. If an arteriole constricts, resistance increase, blood flow decreases

BP and flow is coordinated by CNS.
Primary function is to ensure enough blood flow to the brain and heart by maintaining MAP.
CVCC is constantly monitoring and adjusting output as required to maintain homeostasis.
It has ability to alter function in a tissue spesific manner.
e.g. After communicating with thermoregulartory centers, CVVV alter blood flow to the skin.
Brain-gut communication after a meal increaes blood flow to intestinal track.

Blood Pressure

Strech sensitive mechanoreceptors known as **baroreceptors** are located in the walls of carotid arteries and aorta where they monitor pressure of blow flowing to brain and the body. CVCC integrates and initiates a rapid response, as a change in CO and PR.

Once blood reaches the capillaries, the plasma and cells exchange materials across thin capillary walls. Tissues with higher metabolic rate require more oxygen and nutrients, so have more capillaries like muscles and glands. Subcutaneous tissue and cartilage have lowest capillary density.

Capillaries have thinnest wall composed of a single layer of flattened endothelial cells. Diameter is barely that of a RBC. Cell junctions determine leakiness.
Continous; endothelial cells are joined to one another with leaky junctions.
Fenestrated; have large pores that allow high volumes of fluid to pass.

Bone marrow, liver and spleen so not have typical capillaries. They have modified vessels called sinusoids, 5 times wider than a capillary. They have fenestrations to allow the passage of blood cells and plasma proteins.

Velocity of flow depends on total cross-sectional area of the vessels. The greater the total cross-sectional area the slower the velocity. Velocity is slowest at the capillaries. Although the diameter of a capillary is smaller than any other vessel its total cross-sectional area is greater than any other.

If bulk flow is into the capillary, fluid movement is called **absorption**; if it is out of capillary, fluid movement is known as **filtration**. Filtration is caused by hydrostatic pressure through leaky cell junctions. Net Filtration at arterial end; net absorption ar the venous end.

is a network of small organs (**lymph nodes**) and tubes (**lympathic vessels**) through which **lymph** flows.

Functions of lymphathic system:

- Returning fluid and proteins filtered out of the capillaries to the circulatory system.
- Picking up fat absorbed at small intestine and transferring it into the circulatory system
- Serving as a filter to help capture and destroy foreign pathogens.