Cardiovascular System – Regulating Mechanisms

Purpose of Regulating Mechanisms

1. Increase blood supply to active tissues and decrease it to inactive tissues
2. Increase or decrease heat loss from the body by redistributing blood
3. Maintain blood supply to vital organs – the heart and brain – at all times
4. Maintain blood pressure (MAP)

Types of RM – for the control of circulation

- Local (intrinsic)
- Humoral (extrinsic)
- Neural (extrinsic)

Local Control Mechanisms

- Most tissues have the capacity to control their own blood flow by local control mechanisms
- These mechanisms allow the individual vascular beds to maintain a relatively constant blood flow when moderate changes occur in blood pressure
- Two theories:
    - Myogenic Theory (autoregulation)
    - Metabolic Theory

Myogenic Theory

- Occurs as a result of local changes in blood flow to capillary beds due to changes in *local blood pressure*
- Causes either constriction or relaxation of the smooth muscle in the arterioles
- Found in heart, brain and kidney (very important in these areas)

Sudden increase in blood pressure

↓

Stretches wall of arterioles

↓

Smooth muscle in walls contract

↓

Vasoconstriction

↓

Decreased blood flow and pressure

*doesn't need nervous system

Metabolic Theory

- Activity within a tissue releases metabolic by-products (vasodilator metabolites [VDMs])
- Causes a very local vasodilation of the blood vessels leading to increase in blood flow in that tissue
- Metabolites that will INCREASE blood flow (at the level of the arteriole/precapillary sphincter)
    - Increased CO_2
    - Increased $[H^+]$ (increased acidity = decreased pH)
    - Increased adenosine (from ATP breakdown)
    - Increased temperature
    - Decreased O_2
- If VDMs decrease (or O_2 increases), CONSTRICTION occurs

Humoral Control Mechanisms

- Substances (hormones) in the blood that cause vasoconstriction or vasodilation
- Fall into 2 categories

Vasoconstrictor Agents

- Epinephrine (or adrenaline)
    - Released by SNS
    - Attaches to alpha receptors in blood vessels throughout body
    - Overall weak vasoconstriction
- Angiotensin II
    - Renal system
    - Post potent vasoconstrictor
- Vasopressin (ADH)
    - Renal system

Vasodilator Agents

- Epinephrine (or adrenaline)
    - Released by SNS
    - Attaches to beta receptors in blood vessels of skeletal and cardiac muscle and the liver
- Kinins
    - Proteins found in plasma
- Histamine
    - Released by damaged cells
- Atrial Natriuretic Factor (ANF)
    - Released by atrial muscle cells

Neural Control Mechanisms

- Both branches of the ANS (sympathetic and parasympathetic) can induce rapid changes in blood flow by causing vasodilation or vasoconstriction

Effects of Sympathetic Nervous System on blood vessels

- NT norepinephrine released onto blood vessels causes a general vasoconstriction
- NT acetylcholine released onto skeletal muscle causes a vasodilation
    - Also causes the release of epinephrine from adrenal glands

Baroreceptor Reflex

- Negative feedback system
- Works to maintain normal mean arterial pressure (MAP) for proper perfusion of tissues throughout the body
- Does this by regulating *cardiac output (CO)* and *total peripheral resistance (TPR)*

Mean Arterial Pressure (MAP)

= the average pressure throughout the entire cardiac cycle and can be calculated by:

$$MAP = CO \times TPR$$

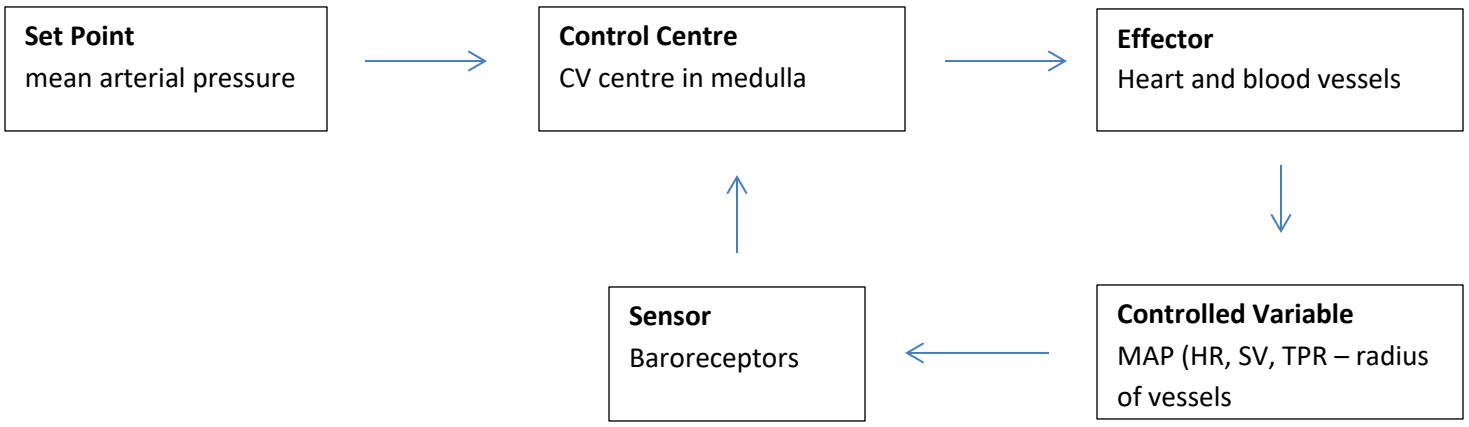
CO – HR x SV

TPR – all the resistance encountered by the blood in the entire systemic circulation – $1/r^4$

↓ radius, ↑ resistance, ↑ MAP

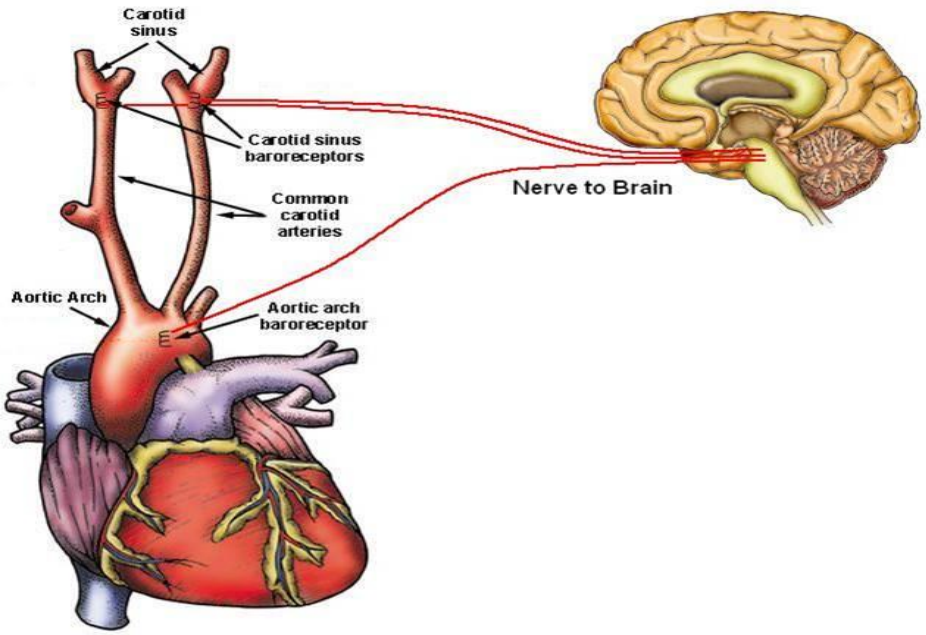
↑ radius, ↓ resistance, ↓ MAP

Negative Feedback Control of MAP



Baroreceptors

- Stretch sensitive sensors
- Monitor blood pressure
- Located in walls of aortic arch and carotid sinuses



Baroreceptor Reflex + sudden increase in blood pressure

Increase in blood pressure (MAP)

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Stretches wall of aorta and carotid sinuses

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Activates baroreceptors

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APs sent to CV centre in medulla of brain stem

↓

CV centre compares signals to set point

↓

Shuts off SNS and activates PNS

↓

Decreased CO (lower HR and SV) and causes vasodilation (decreased TPR)

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Decreased MAP

*and vice versa