Central regulation of viscera

Neural control of autonomic functions

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Introduction to visceral regulation

- Viscera: internal organs (heart, lungs, digestive system, etc.)
- Central regulation maintains homeostasis
- Involves autonomic nervous system (ANS)
- Coordinated by central nervous system structures
- Critical for survival and physiological balance

Control of the autonomic nervous system

The lateral horn cells and brain stem nuclei from which the preganglionic neurons arise are controlled both **reflexly** i.e. by impulses arriving along afferent neurons as well as
by descending impulses from **certain higher centers** in the nervous system

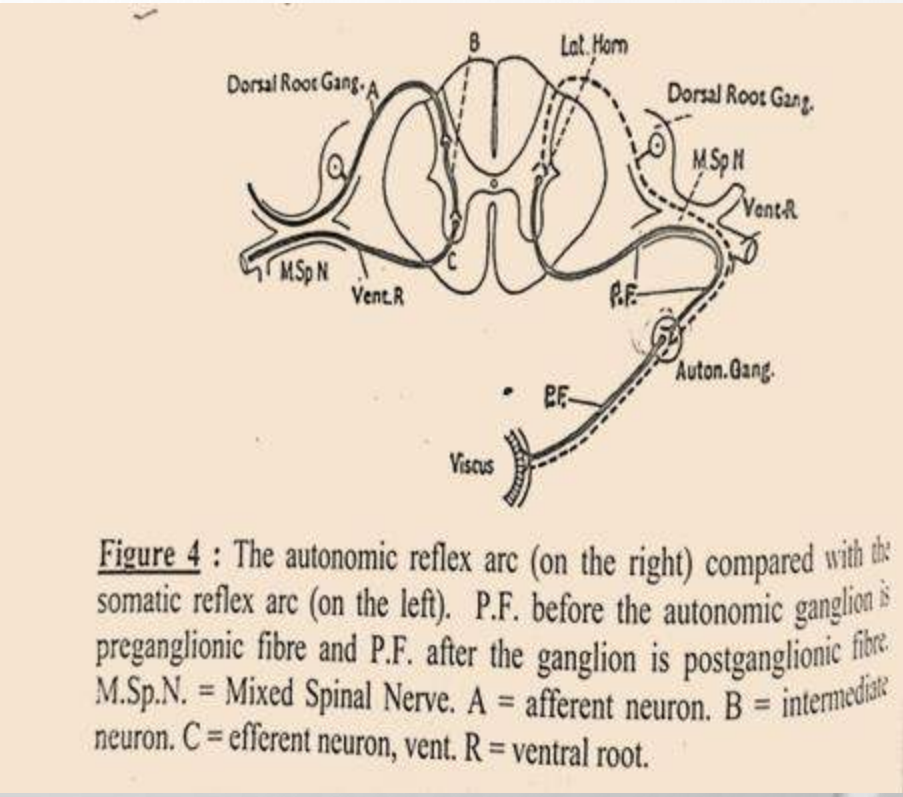

Figure 4 : The autonomic reflex arc (on the right) compared with the somatic reflex arc (on the left). P.F. before the autonomic ganglion is preganglionic fibre and P.F. after the ganglion is postganglionic fibre. M.Sp.N. = Mixed Spinal Nerve. A = afferent neuron. B = intermediate neuron. C = efferent neuron, vent. R = ventral root.

(A) reflex control of autonomic functions

(1) Spinal autonomic reflexes

These produce responses by stimulating the spinal autonomic (the lateral horn cells). Common examples include the following :

- **The micturition, defecation and erection reflexes**

Distention of either the urinary bladder or rectum, or irritation of the penis stimulate certain receptors in these organs which discharge impulses along afferent nerves to the sacral region of the spinal cord, resulting in **micturition , defecation** or **erection** (depending on the stimulated organ) via the sacral parasympathetic outflow.

➢ The peritoneal -visceral reflex

Peritoneal irritation leads to discharge of impulses along afferent nerves to the spinal cord, where they stimulate the sympathetic centers (in the lateral horn cells) which discharge efferent impulses via the splanchnic nerves resulting in relaxation of the visceral walls.

This condition is known as **paralytic or a dynamic ileus**, and is commonly observed following **major abdominal operations** and in cases of **peritonitis**

(2) Brain stem reflexes

Medulla Oblongata

Medullary cardiovascular centers

- Vasomotor center → controls vessel diameter
- Cardiac center → heart rate and contractility
- Baroreceptor reflex →blood pressure regulation

Medullary respiratory centers

- Dorsal respiratory group (DRG) - inspiration
- Ventral respiratory group (VRG) - expiration
- Central chemoreceptors in medulla

Pons

Pontine centers modulate breathing pattern

- Pneumotaxic center → respiratory control
- Apneustic center → inspiratory regulation

Common examples of stimulating the **cranial parasympathetic centers** in the brain stem.

include the following :

- **Reflex salivary, gastric and pancreatic secretion**

Introduction of food in the mouth stimulates the taste and other receptors in the buccal cavity which discharge impulses along afferent nerves to the brain stem where they stimulate the salivary and dorsal vagus nuclei resulting in reflex salivary, gastric and pancreatic secretion.

These responses are called **unconditioned reflexes**

➢ Reflex pupillo-constriction

On exposing the eyes to light (and also during accommodation to near vision), the photo-receptors in the retina are stimulated leading to discharge of impulses in afferent fibers of the optic nerve which stimulate the Edinger-Westphal nucleus in the **midbrain** resulting in miosis (= pupillo-constriction). These reflexes are called the light and near reflexes respectively .

(B) higher control of autonomic functions

- The **higher centers** that **control autonomic functions** include the reticular formation , the hypothalamus and certain areas in the cerebral cortex

1.The reticular formation

The reticular formation is a collection of nerve cells and fibers in the **brain stem** which contains many centers that control autonomic functions, specially the centers in the medulla oblongata that control

- Gastrointestinal functions e.g. the deglutition and vomiting centers
- Cardiovascular functions (the vasomotor and cardio-inhibitory centers).

These centers control the lateral horn cells by discharging impulses via descending nerve fibers called the reticulo-spinal tract

e.g. if the arterial blood pressure is lowered (as occurs in cases of severe hemorrhage) **the vasomotor center** is activated and the descending impulses stimulate the **sympathetic lateral horn cells** leading to **generalized V.C**. in the body as well as heart acceleration, and such responses result in elevation of the arterial blood pressure towards the normal level.

2. The hypothalamus

- Principal integrating center for autonomic functions
- Controls body temperature, hunger, thirst
- Regulates circadian rhythms
- Connects nervous and endocrine systems
- Projects to brainstem and spinal autonomic centers

Examples

- Anterior hypothalamus controls **Parasympathetic & cooling**
- Posterior hypothalamus controls **Sympathetic& heating**
- Lateral hypothalamus controls **Hunger& feeding behavior**
- Ventro-medial nucleus acts as **primary satiety center**
- Supra-chiasmatic nucleus acts as **Circadian pacemaker**
- Paraventricular nucleus controls **Stress response & BP regulation**

The anterior hypothalamic nuclei **control parasympathetic functions** while the posterior hypothalamic nuclei **control sympathetic functions.**

The hypothalamus exerts its effects through affecting the centers located in **the reticular formation**

e.g. in certain emotions, impulses are discharged from the hypothalamus to the medulla oblongata where they stimulate the **vasomotor center** leading to **generalized V.C** and **tachycardia** (= increased heart rate) through stimulating the sympathetic nervous system.

These effects are augmented by catechol-amines released from the **adrenal medullae**, and result in marked rise of the arterial blood pressure.

3. The cerebral cortex

This controls the autonomic centers in both the hypothalamus and reticular formation.

Examples of the cortical control on autonomic functions include the following:

(a) Cortical signals lead V.D in skeletal muscles on performing muscular exercise via **the sympathetic V.D. system**.

(b) Prolonged mental work stimulates the vasomotor center and frequently leads to chronic hypertension.

(c) Cortical impulses increase the heart rate during certain emotions.

(d) Thinking of food induces salivation as well as gastric and pancreatic secretion by cortical signals that stimulate the salivary and vagal nuclei in the brain stem. These responses are called **conditioned reflexes** .

Central stress response

- Hypothalamic-pituitary-adrenal (HPA) axis
- PVN releases CRH → ACTH → cortisol
- **Sympathetic activation**
- Increased heart rate and blood pressure
- Bronchodilation
- Glucose mobilization
- Suppression of non-essential functions

Integration of visceral control

Multi-level organization

- Spinal reflexes (simple, rapid)
- Brainstem integration (coordinated reflexes)
- Hypothalamic regulation (homeostasis)
- Limbic/cortical modulation (emotional/voluntary)
- Feedback loops maintain homeostasis
- Redundancy ensures vital function preservation

THANK YOU