"Reticular Formation And Limbic System (Part 1/1)"

<- Reticular Formation ->

》 Overview

- The reticular formation is a network of nerve cells and fibers resembling a net, extending through the central nervous system (CNS) from the spinal cord to the cerebrum.
- It integrates sensory inputs, influences various bodily functions, and modulates consciousness.

》 General Arrangement

> Structure:

- The reticular formation consists of a network of nerve cells and fibers from the spinal cord through the medulla, pons, midbrain, subthalamus, hypothalamus, and thalamus.

- It is divided into three longitudinal columns:

• Median Column: Located in the median plane, containing intermediate-sized neurons.

• Medial Column: Contains large neurons.

• Lateral Column: Composed mainly of small neurons.

》 Neurochemical Organization:

- Traditional staining techniques show poorly defined neuron groups.
- However, modern neurochemical methods reveal organized, transmitter-specific cell groups that influence specific CNS areas.
- The reticular formation contains both crossed and uncrossed pathways, supporting both somatic and visceral functions.

》 Continuity and Connections:

- Inferiorly, it connects with the spinal cord's gray matter.
- Superiorly, it projects to the cerebral cortex and the cerebellum.

》 Afferent Projections

> Sources:

- Spinal Cord: Includes spinoreticular, spinothalamic tracts, and medial lemniscus.
- Cranial Nerve Nuclei: Receives inputs from vestibular, acoustic, and visual pathways.
- Cerebellum: Projects via the cerebelloreticular pathway.

> Other

CNS Regions: Includes inputs from subthalamic, hypothalamic, thalamic nuclei, corpus striatum, limbic system, and the primary motor and somesthetic cortices.

» Efferent Projections

> Pathways:

- To Brainstem and Spinal Cord:
  - Via reticulobulbar and reticulospinal tracts
  - Affects motor nuclei of cranial nerves and spinal cord anterior horn cells.

- Autonomic Nervous System:
  - Extends to sympathetic and parasympathetic outflows.

- Other CNS Regions: Projects to:
  - Corpus striatum
  - Cerebellum
  - Red nucleus
  - Substantia nigra
  - Tectum
  - Thalamic, subthalamic, and hypothalamic nuclei.

- Cerebral Cortex:
  - Most regions of the cerebral cortex receive efferent fibers from the reticular formation.

》 Functions of the Reticular Formation

- The reticular formation is involved in numerous functions due to its extensive connections throughout the nervous system. Here are some of its key roles:

1) Control of Skeletal Muscle

> Influence on Motor Neurons:

- The reticular formation affects alpha and gamma motor neurons via reticulospinal and reticulobulbar tracts.
- It modulates muscle tone, reflexes, and reciprocal inhibition (e.g., contraction of flexor muscles leading to relaxation of antagonistic extensors).

> Role in Posture:

- It assists in maintaining the tone of antigravity muscles while standing, in conjunction with the vestibular apparatus and vestibulospinal tract.

> Respiratory Control:

- Respiratory centers in the brainstem, once considered separate, are now regarded as part of the reticular formation.

2) Control of Facial Expression Muscles

> Emotional Expression:

- The reticular formation regulates facial expression muscles involved in emotions.
- It operates independently from the corticobulbar fibers, allowing symmetric smiles even if facial paralysis occurs due to corticobulbar fiber damage.

3) Control of Somatic and Visceral Sensations

> Influence on Sensory Pathways:

- The reticular formation affects all ascending sensory pathways passing to higher brain levels.
- It can either facilitate or inhibit sensory input, including playing a role in the "gating mechanism" for pain perception.

4) Control of the Autonomic Nervous System (ANS)

> Higher Control:

- The reticular formation, through reticulobulbar and reticulospinal tracts, modulates sympathetic and parasympathetic ANS outflows.

5) Control of the Endocrine System

> Influence on Hormone Release:

- It affects the synthesis and release of hormonal factors either directly or through the hypothalamic nuclei, impacting the hypophysis cerebri (pituitary gland).

6) Influence on Biological Clocks

> Regulation of Biological Rhythms:

- By interacting with the hypothalamus, the reticular formation likely influences biological rhythms and sleep-wake cycles.

7) Reticular Activating System

> Arousal and Consciousness:

- The reticular formation regulates arousal and consciousness levels by channeling sensory information to the cerebral cortex.
- It plays a crucial role in waking a person from sleep and modulating the state of consciousness.
- Acetylcholine is a key neurotransmitter in this arousal process, with increased activity during pain sensations elevating cortical activity.

<- Limbic System ->

》 Definition and Function

- "Limbic" means border or margin
- Includes structures between the cerebral cortex and hypothalamus
- Involved in emotion, behavior, drive, and memory

》 Anatomical Structures

> Gyri: Subcallosal, cingulate, parahippocampal

> Other Structures: Hippocampal formation, amygdaloid nucleus, mammillary bodies, anterior thalamic nucleus

> Connecting Pathways: Alveus, fimbria, fornix, mammillothalamic tract, stria terminalis

"Hippocampal Formation"

》 Components

> Hippocampus:

- Curved elevation of gray matter in the floor of the inferior horn of the lateral ventricle
- Anterior end: Expanded to form pes hippocampus
- Resembles a seahorse in coronal section
- Covered with ependyma; beneath is the white matter layer called alveus

> Alveus:

- Nerve fibers originating in the hippocampus; converge to form the fimbria

> Fimbria:

- Becomes continuous with the crus of the fornix
- Terminates posteriorly beneath the splenium of the corpus callosum

> Dentate Gyrus:

- Narrow, notched band of gray matter
- Lies between fimbria of hippocampus and parahippocampal gyrus
- Continuous with the indusium griseum posteriorly

> Indusium Griseum:

- Thin, vestigial gray matter layer on the superior surface of the corpus callosum
- Contains medial and lateral longitudinal striae
- Anteriorly continues into the uncus

> Parahippocampal Gyrus:

- Lies between hippocampal fissure and collateral sulcus
- Continuous with the hippocampus along the medial edge of the temporal lobe

"Amygdaloid Nucleus"

》 Location and Structure

- Resembles an almond
- Located partly anterior and superior to the tip of the inferior horn of the lateral ventricle
- Fused with the tip of the caudate nucleus
- Stria terminalis emerges from its posterior aspect

》 Nuclei Groups

- Larger basolateral group
- Smaller corticomedial group

》 Connecting Pathways of the Limbic System

> Alveus

- Thin layer of white matter on the superior or ventricular surface of the hippocampus
- Composed of nerve fibers originating in the hippocampal cortex
- Fibers converge on the medial border of the hippocampus to form the fimbria

> Fimbria

- Leaves the posterior end of the hippocampus as the crus of the fornix
- Crus curves posteriorly and superiorly beneath the splenium of the corpus callosum and around the thalamus
- Two crura converge to form the body of the fornix
- Connected by transverse fibers called the commissure of the fornix
- Commissure decussates and joins the hippocampi of both sides

> Fornix

- Body of the fornix applied closely to the undersurface of the corpus callosum
- Anteriorly connected to the corpus callosum by the septum pellucidum
- Inferiorly related to the tela choroidea and ependymal roof of the third ventricle
- Splits anteriorly into two anterior columns
- Columns curve anteriorly and inferiorly over the interventricular foramen (foramen of Monro)

- Columns disappear into the lateral wall of the third ventricle to reach the mammillary body

> Mammillothalamic Tract

- Provides connections between the mammillary body and the anterior nuclear group of the thalamus

> Stria Terminalis

- Emerges from the posterior aspect of the amygdaloid nucleus
- Runs posteriorly in the roof of the inferior horn of the lateral ventricle
- Lies on the medial side of the tail of the caudate nucleus
- Follows the curve of the caudate nucleus to the floor of the body of the lateral ventricle

"Hippocampal Structure and the Dentate Gyrus"

》 Parahippocampal Gyrus

- Six-layered cortical structure

- Gradual transition from six to three layers in the hippocampus

> Superficial Molecular Layer: Nerve fibers and scattered small neurons

> Pyramidal Layer: Large pyramid-shaped neurons

> Inner Polymorphic Layer: Similar to the polymorphic layer of other cortical regions

》 Dentate Gyrus

- Three layers, with the granular layer replacing the pyramidal layer

> Granular Layer: Densely arranged rounded or oval neurons

- Axons terminate on dendrites of pyramidal cells in the hippocampus

- Some axons join the fimbria and enter the fornix

"Afferent Connections of the Hippocampus"

》 Six Groups of Afferent Fibers:

1) Fibers arising in the cingulate gyrus pass to the hippocampus.

2) Fibers from the septal nuclei (located near the midline close to the anterior commissure) pass posteriorly in the fornix to the hippocampus.

3) Fibers from one hippocampus cross the midline to the opposite hippocampus in the commissure of the fornix.

4) Fibers from the indusium griseum pass posteriorly in the longitudinal striae to the hippocampus.

5) Fibers from the entorhinal area or olfactory-associated cortex pass to the hippocampus.

6) Fibers from the dentate and parahippocampal gyri travel to the hippocampus.

"Efferent Connections of the Hippocampus"

》 Pathway of Axons:

- Axons of large pyramidal cells form the alveus and the fimbria.
- The fimbria continues as the crus of the fornix.
- The two crura converge to form the body of the fornix.
- The body of the fornix splits into two columns which curve downward and forward in front of the interventricular foramina.

》 Distribution of Fornix Fibers:

1) Fibers pass posterior to the anterior commissure to enter the mammillary body, ending in the medial nucleus.

2) Fibers pass posterior to the anterior commissure to end in the anterior nuclei of the thalamus.

3) Fibers pass posterior to the anterior commissure to enter the tegmentum of the midbrain.

4) Fibers pass anterior to the anterior commissure to end in the septal nuclei, lateral preoptic area, and anterior part of the hypothalamus.

5) Fibers join the stria medullaris thalami to reach the habenular nuclei.

》 Considerations:

- Limbic system structures are interconnected and send projection fibers to various parts of the nervous system.

- The hypothalamus is recognized as the major output pathway of the limbic system.

》 Limbic System Functions

1) Influence on Emotional Behavior:

• Mediated by:

- Hypothalamus.
- Connections with autonomic nervous system (ANS) outflow.
- Control of the endocrine system.

2) Emotional Reactions Affected

- Fear and anger.

- Emotions associated with sexual behavior.

3) Role in Memory:

• Hippocampus:

- Converts recent memory into long-term memory.
- Lesions result in inability to store long-term memory (anterograde amnesia).
- Memory of remote past events before the lesion remains unaffected.

4) Impact of Injuries:

- Combined injury to the amygdaloid nucleus and hippocampus causes greater memory loss than injury to either structure alone.

5) Olfactory Function:

- No evidence supports a direct olfactory function of the limbic system.

6) Pathways for Integration and Homeostasis:

- Afferent and efferent connections provide pathways for integrating and achieving homeostatic responses to various environmental stimuli.

"Clinical Notes"

》 Reticular Formation

> Structure:

- A continuous network of nerve cells and fibers from the spinal cord to the cerebral cortex.
- Modulates motor control and influences sensory systems.
- Ascending pathways project to various parts of the cerebral cortex, influencing consciousness.

> Loss of Consciousness:

- Damage to the reticular formation (sparing ascending sensory pathways) in experimental animals causes persistent unconsciousness.
- Pathologic lesions in humans can result in loss of consciousness and coma.
- In epilepsy, loss of consciousness may be due to inhibition of the reticular formation in the upper diencephalon.

》 Limbic System

> Connections:

- Anatomical connections are complex; detailed memorization is unnecessary.
- Results from neurophysiologic experiments (stimulation and ablation) are unclear but suggest important roles.

> Inferred Roles:

- Limbic structures develop sensations of emotion and visceral responses.
- The hippocampus is involved in recent memory.

> Schizophrenia

• Symptoms:

- Disordered thinking, blunted affect, emotional withdrawal.
- Paranoid delusions and auditory hallucinations may occur.

• Treatment:

- Blocking dopamine receptors in the limbic system can lessen severe symptoms (e.g., Phenothiazine).
- Most antipsychotic drugs, including Phenothiazine, have motor side effects due to blocking dopaminergic receptors in the extrapyramidal system (substantia nigra–corpus striatum).
- Research aims to find drugs that block limbic dopamine receptors without affecting the extrapyramidal system.

• Dopamine Production:

- No direct evidence suggests that excessive dopamine production by neurons contributes to schizophrenia.

》 Amygdaloid Complex Destruction

> Effects in Patients:

- Unilateral or bilateral destruction of the amygdaloid nucleus and para-amygdaloid area.

> Results:

- Decrease in aggressiveness, emotional instability, and restlessness.
- Increased interest in food and hypersexuality.
- No impact on memory.

》 Klüver-Bucy Syndrome (Monkeys)

- Occurs after bilateral removal of temporal lobes

> Symptoms:

- Docility and lack of fear or anger.
- Inability to recognize objects visually.
- Increased appetite and sexual activity.
- Indiscriminate sexual behavior with both male and female animals.

» Stereotactic Lesions in Humans:

- Precise lesions in the amygdaloid complex.

> Effects

- Reduction in emotional excitability.
- Normalization of behavior in patients with severe disturbances.
- No memory loss.

» Temporal Lobe Dysfunction

> Temporal Lobe Epilepsy:

- May be preceded by an aura (acoustic or olfactory).
- Olfactory aura typically involves an unpleasant odor.
- Symptoms during seizure:
- Confusion, anxiety, and docility.
- Performance of automatic, complex movements (e.g., undressing in public, driving a car).
- Post-seizure: No memory of actions performed during the seizure.