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Diencephalon

M1 – CNS Sequence
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Winter, 2009
Introduction to today’s lecture:

I. Introduction to the Diencephalon (inter brain)
II. Anatomical subdivisions of the Diencephalon
III. Anatomical Boundaries of the Diencephalon - 3rd ventricle and internal capsule
IV. Dorsal thalamus - Organization and functional considerations
V. Interconnections between Dorsal Thalamus and Cerebral Cortex
VI. Ventral Thalamus
VII. Hypothalamus - Organization and functional considerations
VIII. Interconnections of the Hypothalamus
IX. Blood supply to the Dorsal Thalamus and Hypothalamus
In the adult brain the diencephalon is completely surrounded by the telencephalon.

Regions of the Diencephalon:

A. Epithalamus (pineal gland and habenula)
B. Dorsal Thalamus
C. Hypothalamus
D. Ventral thalamus (or subthalamus) (not visible in this midline section)
E. Posterior pituitary

mi. massa intermedia - adhesion between dorsal thalami
The **thalamus** (th) and **hypothalamus** (hy) form the walls and floor of the **third ventricle** (III).

The roof of the ventricle (in green) extends from the interventricular foramen to the pineal gland.

The massa intermedia (mi) connects the left and right thalami in about 70% of human brains.

This bridge of tissue divides the third ventricle into upper and lower channels.
The fibers of the **Internal Capsule** form the lateral boundary of the diencephalon.

Most of the fibers in the internal capsule are reciprocal connections between the thalamus and the cerebral cortex, the **thalamo-cortical** and **cortico-thalamic** fibers.
Organization of Dorsal Thalamus - Four general principles:

1) The dorsal thalamus consists of two symmetrical, ovoid nuclei (many nuclei, actually) located in the diencephalon.

2) The dorsal thalamus is the principal relay structure for all sensory and motor information destined for the ipsilateral cerebral cortex. 
   • The one exception to this rule is olfactory information passes through the thalamus only indirectly.

3) Each half of the dorsal thalamus can be divided into numerous (about 26) nuclei, which receive particular inputs and send their axons to cortex in anatomically defined patterns.

4) Thalamic nuclei receive reciprocal connections from the cortex.
The Functional Areas of the Cerebral Cortex

Motor Association Cortex

Limbic Lobe Cortex

Multimodal Behavioral Association Cortex

Multimodal Sensory Association Cortex

M1 primary motor cortex
S1 primary somatosensory cortex
V1 primary visual cortex
A1 primary auditory cortex

Posterior cerebral cortex analyzes and integrates sensory information.

Dorso-lateral view of the left dorsal thalamus

primary sensory cortical areas:
S1  A1  V1
VPL  MGN  LGN & VPM

multimodal sensory association cortex

pulvinar & lateral posterior nuclei

The frontal lobe orchestrates behavior.

motor cortex (M1) & motor association areas (MA)

limbic lobe

frontal association cortex

ventral anterior & ventral lateral nuclei

anterior & lateral dorsal nuclei

medial dorsal nucleus

ventral anterior & ventral lateral nuclei

ventral posterior nuclei (VPL and VPM)

lateral geniculate nucleus (LGN)

medial geniculate nucleus (MGN)

ventral posterior nucleus

lateral posterior nucleus

pulvinar

medial dorsal nucleus

lateral dorsal nucleus

anterior nuclei

ventral lateral nucleus

ventral posterior nucleus (VPL and VPM)
Reciprocal connections between thalamus and cortex are found in four limbs of the internal capsule:

- anterior limb with frontal lobe
- posterior limb with parietal lobe
- retrolenticular limb with occipital lobe
- sublenticular limb with temporal lobe

The genu contains the corticobulbar axons. Corticospinal axons are in the posterior limb. Corticopontine axons are in both the anterior and posterior limbs.
What does the Dorsal Thalamus do? - Functional considerations

• The dorsal thalamus controls the flow of numerous streams of information to the cerebral cortex (origins - basal ganglia, hypothalamus, spinal cord, etc.)

• Only 5-10% of the synapses in the thalamus come from the afferents (the driving input). 90-95% of the synapses in the thalamus are modulatory and originate local inhibitory neurons and descending inputs from cerebral cortex.

• The dorsal thalamus is not a simple machine-like relay from a peripheral receptor to layer 4 of the cortex. The dorsal thalamus is a center that serves to control the flow of information from the periphery to the cortex.

• Cortical feedback to the dorsal thalamus plays a role in gating information that reaches the cerebral cortex. This feedback contributes to selective attention, enhanced responses for relevant stimuli and suppressed responses for distractive stimuli.

• Injuries to dorsal thalamus can result in sensory, motor and/or cognitive deficits.
The ventral thalamus is lateral to the caudal part of the hypothalamus (hy). The **subthalamic nucleus** (su) is the largest nucleus in the ventral thalamus.

The subthalamic nucleus (su) and substantia nigra (sn) belong to the basal ganglia.

The substantia nigra is in the base of the midbrain.
The Hypothalamus

The part of the diencephalon that controls visceromotor and endocrine functions and affective (emotional) behavior.

Organization
• rostrocaudal axis
• mediolateral axis - periventricular, medial, lateral

Major functions:
• Control of the pituitary gland (both anterior and posterior)
• Control of the autonomic nervous system
• Control of a variety of behaviors that are essential for survival (of the individual and of the species): eating, drinking, sleep, sexual behavior, parental behavior, and aggression.
• Partially regulate water balance, food intake, body temperature, blood pressure, body metabolism, etc.
The hypothalamus is a matrix of nuclei:
- Preoptic area
- Supraoptic area
- Tuberal area
- Mamillary area

Rostrocaudal organization

Netter’s images of hypothalamus removed
Medial-lateral organization

Periventricular – hormone release from anterior pituitary

Middle - numerous discrete Nuclei; anterior and posterior pituitary; autonomic nervous system

Lateral - few discrete nuclei; cardiovascular function; regulation of food and water intake
The hypothalamus has reciprocal connections with the:

• Hippocampus
• Amygdala
• Brainstem tegmentum
• Thalamus (anterior/dorsomedial nuclei)
• Neocortex
Blood supply to the dorsal thalamus

Thalamoperforating artery supplies the anterior dorsal thalamus

Thalamogeniculate artery supplies the posterior thalamus and geniculate bodies

Branches from the middle cerebral artery supply the internal capsule.

Occlusion of the lenticulostriate arteries is a common cause of strokes that produce contralateral hemiplegia.
The hypothalamus is supplied with blood by small perforating branches from the Circle of Willis.
Slide 5: The Anatomy of the Nervous System: From the Standpoint of Development and Function, SW Ranson
Slide 6: Source Undetermined; The Anatomy of the Nervous System: From the Standpoint of Development and Function, SW Ranson
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