Thalamus and Limbic System

Please view our Editing File before studying this lecture to check for any changes.

Color Code
- **Important**
- **Doctors Notes**
- **Notes/Extra explanation**
Objectives

At the end of the lecture, the students should be able to:
✓ Describe the anatomy and main functions of the thalamus.
✓ Name and identify different nuclei of the thalamus.
✓ Describe the main connections and functions of thalamic nuclei.
✓ Name and identify different parts of the limbic system.
✓ Describe main functions of the limbic system.
✓ Describe the effects of lesions of the limbic system.
Thalamus

- It is the largest nuclear mass of the whole body.
- It is the largest part of the **diencephalon**
- It is formed of: two oval masses of **grey matter**.
- It is the gateway to the cortex. (the last station for sensory fibers before it project to the cortex)
- Resemble a small hen.
- Together with the hypothalamus they form the lateral wall of the **3rd ventricle**.

- The **thalamus** sends received information to the cerebral cortex from **different brain regions**.
- Axons from every sensory system (except olfaction) synapse in the thalamus as the last relay site 'last pit stop' before the information reaches the cerebral cortex.
- There are some thalamic nuclei that receive input from:
  1. Cerebellar nuclei,
  2. Basal ganglia
  3. Limbic-related brain regions.
It has 4 surfaces & 2 ends.

**Surfaces:**

- **Superior:** (S)
  - Lateral ventricle and fornix.

- **Inferior:** (I)
  - Hypothalamus, anteriorly & Subthalamus posteriorly.

- **Medial:** (3)
  - The 3rd ventricle In some people it is connected to the thalamus of the opposite side by the interthalamic connexus, (adhesion) or Massa intermedia.

- **Lateral:** (L)
  - Posterior limb of the internal capsule.

**Ends:**

- **Anterior end:**
  - Forms a projection, called the anterior tubercle. It lies just behind the interventricular foramen*.

- **Posterior end:** (Broad عريض)
  - Forms a projection called Pulvinar which lies above the superior colliculus and the lateral & medial Geniculate bodies.

*the foramen between the lateral ventricle and the 3rd ventricle.
Thalamus

Internal Structure

White matter:

- **External medullary lamina**: Lamina or fiber
  - Covers the lateral surface.
  - It consists of **thalamocortical** & **corticothalamic** fibers.

- **Internal medullary lamina**
  - Bundle of Y-shaped myelinated (afferent & efferent) fibers.
  - It divides the thalamus into: **anterior**, **medial**, and **lateral nuclear** groups.
  - Each of these groups is subdivided into a number of named nuclei.

*Has a relation with limbic system

- Embedded within the **internal medullary lamina** lie the **intralaminar nuclei**.
- The **external medullary lamina** covers the lateral surface; in which lies the **reticular nucleus**.

*Only on the boys’ slides*
Thalamus
Lateral Nuclear Group

Lateral Nuclear Group is divided into: **Dorsal & Ventral tiers**

<table>
<thead>
<tr>
<th>Dorsal Tier</th>
<th>Ventral Tier</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Lateral Dorsal (LD)</td>
<td>1. Ventral Anterior (VA)</td>
</tr>
<tr>
<td></td>
<td>2. Ventral Lateral (VL)</td>
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<tr>
<td>2. Lateral Posterior (LP)</td>
<td>3. Ventral Intermediate (VI)</td>
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<td></td>
<td>4. Ventral Posterior (VP) (lateral: PLVNT &amp; medial: PMVNT)</td>
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<tr>
<td>3. Pulvinar</td>
<td>5. Medial geniculate nuclei</td>
</tr>
<tr>
<td></td>
<td>6. Lateral geniculate nuclei</td>
</tr>
</tbody>
</table>

**Extra tier** = group

VL and VI are the same (have the same function)
Thalamus
Projection of Nuclei

This slide is important!

<table>
<thead>
<tr>
<th>Afferent</th>
<th>Efferent</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Anterior Thalamic Nucleus</strong></td>
<td>Mammillary body.</td>
</tr>
<tr>
<td></td>
<td>Which is part from hypothalamus</td>
</tr>
<tr>
<td></td>
<td>Cingulate gyrus, (part of limbic system)</td>
</tr>
<tr>
<td><strong>Medial Nucleus</strong></td>
<td>Hypothalamus.</td>
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<tr>
<td></td>
<td>Prefrontal cortex &amp;</td>
</tr>
<tr>
<td></td>
<td>Frontal cortex</td>
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<td></td>
<td><em>Only on the girls’ slides</em></td>
</tr>
<tr>
<td><strong>Ventral Anterior Nucleus</strong></td>
<td>Globus pallidus body</td>
</tr>
<tr>
<td></td>
<td>and substantia nigra.</td>
</tr>
<tr>
<td></td>
<td>Premotor cortex. In frontal lobe</td>
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<td><em>Only on the boys’ slides</em></td>
</tr>
<tr>
<td><strong>Ventral Lateral Nucleus and VI</strong></td>
<td>Dentate Nucleus</td>
</tr>
<tr>
<td></td>
<td>From cerebellum</td>
</tr>
<tr>
<td></td>
<td>Primary Motor Cortex.</td>
</tr>
<tr>
<td></td>
<td>In frontal lobe in precentral gyrus</td>
</tr>
<tr>
<td><strong>Ventral Posterior Lateral Nucleus</strong></td>
<td>Medial and Spinal</td>
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<td></td>
<td>leminisci.</td>
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<tr>
<td></td>
<td>Sensory Cortex. In</td>
</tr>
<tr>
<td></td>
<td><em>Postcentral gyrus in partial lobe</em></td>
</tr>
<tr>
<td><strong>Ventral Posterior Medial Nucleus</strong></td>
<td>Trigeminal Lemminiscus</td>
</tr>
<tr>
<td></td>
<td>Sensory Cortex.</td>
</tr>
<tr>
<td><strong>Lateral Geniculate Nucleus</strong></td>
<td>Optic tract</td>
</tr>
<tr>
<td></td>
<td>Visual Cortex. In</td>
</tr>
<tr>
<td></td>
<td><em>In occipital lobe</em></td>
</tr>
<tr>
<td><strong>Medial Geniculate Nucleus</strong></td>
<td>Lateral Lemminiscus</td>
</tr>
<tr>
<td></td>
<td>Auditory Cortex. In</td>
</tr>
<tr>
<td></td>
<td><em>In superior temporal lobe</em></td>
</tr>
</tbody>
</table>
Globus pallidus and Substantia Nigra
Mammillary Body
Hypothalamus
Medial & Spinal Leminsci
Dentate Nucleus
Trigeminal Leminscus
Optic Tract
Lateral Leminscus

Helpful picture to review
Limbic System

- The term "limbic" is from the Latin word *Limbus*, for "border" or "edge".
- It separates the medial surface of the cerebral cortex from the diencephalon.
- It consists of a number of cortical & subcortical structures with looped connections that all project to the hypothalamus (*particularly mammillary bodies*).
What is the function of the limbic system?

It controls a variety of functions including:

- **Emotions**
- **Emotional responses**
- **Behavior & Mood** (happy, cry, laugh, sad, afraid, aggression, depression)
- **Motivation**
- **Memory**
- **Visceral & Motor responses** involved in (sex, pleasure, hunger, and reproduction)
- **Olfaction**

These are the general functions of the limbic system but certain parts are more responsible for certain things, ex: hippocampus and memory.
**Limbic System**

- The limbic system is composed of four main structures:
  1. Limbic cortex
  2. Amygdala.
  3. Hippocampus
  4. Septal area.

- These structures form connections between the limbic system and the hypothalamus, thalamus and cerebral cortex.

- The **hippocampus** is important in **memory** and **learning**, while the limbic system itself is important in the control of the **emotional responses**.
**Limbic System**

1. Limbic lobe.
2. Hippocampal formation.
3. Septal areas (Fornix, connecting the hippocampus with mammillary bodies and septal nuclei).
4. Prefrontal area (part of olfactory system).

**CORTICAL STRUCTURES**

**Limbic Lobe**

- C-shaped ring of **grey matter** on the **medial side** of each cerebral hemisphere, surrounding the corpus callosum.
- **It includes:**
  1. Subcallosal area
  2. Cingulate gyrus
  3. Isthmus
  4. Parahippocampal gyrus
  5. Uncus.

**Note:** Subcortical structures are like amygdala and hypothalamus.
Hippocampus

- It is a **limbic system** structure that is involved in:
  - Formation,
  - Organization, and
  - Storage of memories.
- It is important in forming new memories and connecting emotions and senses, such as smell and sound, to memories.
- It is a horseshoe paired structure, one in each cerebral hemisphere.
- It acts as a **memory indexer** by sending memories to the appropriate part of the **cerebral hemisphere** for long-term **storage** and **retrieving** them when necessary.

Extra:
A patient once had his hippocampus removed as a treatment for seizures. After the surgery the seizures stopped but the patient was not able retain or make any new memories.
To learn more about this patient:
https://bigpictureeducation.com/brain-case-study-patient-hm
https://www.youtube.com/watch?v=KkaXNvzE4pk
Hippocampus

- **SITE:**
  It is a scrolled (infolding) structure in the inferomedial part of the temporal lobe.

- **FUNCTION:**
  Memory (file new memories as they occur).
  The hippocampus & its connections are necessary for consolidation of new short-term memories.

- Its principal efferent pathway is called the: **Fornix**:
  - It is a C-shaped group of fibers connecting the hippocampus with mammillary body.
  - It consists of:
    - **2 Fimbria, 2 Crus, 1 Body & 2 Column.**
    - The **Fornix** is an important component of **PAPEZ CIRCUIT** (based on connecting the hypothalamus with limbic lobe to control emotions).
Amygdala

- **SITE:**
  almond shaped mass of nuclei that lies near (deep within) the temporal pole, close to the tail of the caudate nucleus.

- **FUNCTION:**
  It is involved in
  1. Emotions
     - FEAR
     - Anger
  2. Hormonal secretions

**Connections of Amygdala**

**INPUTS:**
- Association areas of visual, auditory & somatosensory cortices.

**OUTPUTS:**
- Hypothalamus & Autonomic nuclei in the brain stem,

- **LESION:** Lack of emotional responses* & docility

*Specifically fear and anger
Septal Nuclei

- **SITE:**
  Located anterior to the *interventricular septum*

- **MAIN CONNECTIONS:**
  1. To Hypothalamus
  2. To Habenular nuclei*

- **FUNCTION:**
  It is the **pleasure** zone.

*located behind the thalamus
Lesions Associated with Limbic Lobe Disorders

1. Korsakoff’s psychosis
   - Korsakoff syndrome is a chronic memory disorder caused by severe deficiency of thiamine (vitamin B-1) & alcoholic intoxication.
   - (Retrograde = loss of new memories at the time of lesion with loss of retained old memories occurred before the injury & anterograde amnesia = inability to gain new memories)

2. Temporal lobe epilepsy
   - The hippocampus is a common focus site in epilepsy, and can be damaged through chronic seizures.
   - It is sometimes damaged in diseases such as herpes encephalitis.

3. Alzheimer’s disease:
   - The hippocampus is one of the first brain areas to show damage in Alzheimer’s disease.

4. Schizophrenia:
   - mental disorder with inappropriate actions and feelings.

5. Anterograde amnesia
   - the inability to form and retain new memories.
<table>
<thead>
<tr>
<th>Thalamic Internal structures</th>
<th>Thalamic Relations</th>
</tr>
</thead>
<tbody>
<tr>
<td>• External medullary lamina -&gt; consists of thalamocortical &amp; corticothalamic fibers.</td>
<td>Superior surface-&gt; lateral ventricle, fornix</td>
</tr>
<tr>
<td>• Internal medullary lamina -&gt; divides the thalamus into anterior, medial &amp; lateral nuclear groups.</td>
<td>Inferior surface-&gt; hypothalamus, subthalamus</td>
</tr>
</tbody>
</table>

The limbic system
Composed of: limbic cortex, amygdala, hippocampus & septal area.

Memories -> Hippocampus
Fear & Anger -> Amygdala
Hormonal secretions -> Amygdala
Pleasure -> Septal Area

<table>
<thead>
<tr>
<th>Thalamic Lateral nuclear group</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Ventral tier -&gt; lateral dorsal, lateral posterior &amp; pulvinar.</td>
</tr>
<tr>
<td>• Dorsal tier -&gt; ventral anterior, ventral lateral, ventral intermediate, ventral posterior (medial &amp; lateral), medial geniculate nucleus, lateral geniculate nucleus.</td>
</tr>
</tbody>
</table>
1. Which one of these is NOT cortical structure?
   a) Limbic lobe.
   b) Hippocampal formation.
   c) Septal areas.
   d) Amygdala

2. Which one of these is a function of the limbic system?
   a) Memory
   b) Speech
   c) Behavior
   d) A and c

3. What is true about the amygdala?
   a) almond shaped mass
   b) lies far away from the temporal pole
   c) close to the tail of the caudate nucleus.
   d) A and c

4. What is anterograde amnesia?
   a) The inability to make new memories
   b) The inability to retain old memories
   c) Both a and b
   d) None of the above

5. Which of the following is a part of the dorsal tier of the lateral nuclear group?
   a) Ventral Intermediate (VI)
   b) Ventral Posterior (VP) (PLVNT, PMVNT)
   c) Medial & Lateral geniculate nuclei
   d) Lateral posterior

1. Limbic system is composed of four main structures mention 3 only:
   1. Limbic cortex
   2. Amygdala.
   3. Hippocampus

2. The limbic lobe includes 5 parts, mention 2:
   1. Subcallosal area
   2. Cingulate gyrus

3. The amygdala has four functions mention them all:
   1. FEAR
   2. Emotions
   3. Anger
   4. Hormonal secretions
Leaders:
Nawaf AlKhudairy
Jawaher Abanumy

Members:
Abdulmalek alhadlaq
Abdullah jammah
AbdulMohsen alghannam
Mohammed habib
Majed alzain
Abdulrahman almalki
Abdulmohsen alkhalaf
Ameera Niazi
Do'aa abulfattah
Nada Aldakheel
Shatha Alghaihb

References:
1- Girls’ & Boys’ Slides
2- Greys Anatomy for Students
3- TeachMeAnatomy.com