

## Lecture 22 – Thalamus & Cerebral Cortex

### Thalamus (Nolte 5<sup>th</sup> Ed pp 387, Fig 16-1/2/3)

The thalamus is part of the diencephalon. The diencephalon is composed of the following structures: epithalamus (includes pineal gland), dorsal thalamus (referred to as **thalamus**), subthalamus, & hypothalamus.

### Thalamus (Nolte 5<sup>th</sup> Ed pp 391 Fig 16-2)

The thalamus makes up about 80% of the diencephalon. Anteriorly, it extends up to the IV foramen, the floor of the lateral ventricle forms the superior border, and the hypothalamic sulcus is its inferior border. Note the internal cerebral vein just above the thalamus in Fig 16-4. The thalamus acts as a relay station: 1) all sensory pathways with the exception of the olfactory pathway relay in the thalamus → before proceeding to the cerebral cortex, 2) many of the anatomical circuits used by the basal ganglia, cerebellum, and limbic system use relay in the thalamus → before proceeding to the cerebral cortex.

In CT scans, the thalamus appears white due to  $\text{Ca}^{2+}$  deposits – hence good landmark.

### Blood supply of thalamus (Nolte 5<sup>th</sup> Ed pp 402, Netter Plate 133)

The blood supply to the thalamus is mostly from the posterior cerebral artery – of the vertebrobasilar system. Branches of posterior choroidal artery supply dorsomedial regions, and the rest of the thalamus is supplied by perforating branches from the posterior cerebral + posterior communicating arteries.

### Anatomical organisation of thalamus (Nolte 5<sup>th</sup> Ed pp 391, Fig 16-6/7)

We mentioned the thalamus was a major relay station for many neural circuits. Each of these circuits uses different areas of the thalamus, conveniently divided into thalamic nuclei.

A thin strip of myelinated fibres – **internal medullary lamina** – divides the thalamus into medial and lateral groups of nuclei. Anteriorly, the internal medullary lamina splits into two – encompassing the anterior group of thalamic nuclei – referred to as **anterior nucleus** (Fig 16-7A). The anterior nucleus receives input from mamillothalamic tract & hippocampus → and projects to the cingulate gyrus. The internal medullary lamina splits at other locations around additional groups of cells → intralaminar nuclei (two groups: **centromedian (CM)** & **parafascicular nuclei (PF)**). The medial group forms the **dorsomedial nucleus**. The lateral group is further subdivided into a dorsal and ventral area. The dorsal area consist of: **lateral dorsal (LD)**, **lateral posterior (LP)** & **pulvinar nuclei**. Note the LP is continuous with the pulvinar nucleus (together called **pulvinar-LP complex**). The ventral area consists of: **ventral anterior**, **ventral lateral**, **ventral posterior nuclei**. The ventral posterior is subdivided further into: **ventroposterolateral (VPL)** + **ventroposteromedial (VPM)**. Also part of the lateral group of nuclei are the **lateral geniculate nucleus** (projects to visual cortex) + **medial geniculate nucleus** (projects to auditory cortex). These are located on the posterior aspect of the thalamus (just below the pulvinar nucleus)

The dorsomedial nucleus receives input from: amygdala (limbic system) & prefrontal cortex → DM → project back to prefrontal cortex. The VPL is involved in somatosensory information from the body, while VPM is involved in somatosensory information from the head → both project to primary somatosensory cortex. The VL functions in executing movements, while VA functions in planning movements. Hence, VA + VL nuclei are motor relay nuclei, receiving input from basal ganglia (via superior cerebellar peduncle) → and projects to motor areas (i.e.: primary, pre, supplementary). The pulvinar nucleus's function is still unclear. The pulvinar – LP complex is interconnected with the parietal-occipital-temporal association cortex.

### Internal Capsule (Nolte 5<sup>th</sup> Ed pp 405-409, Fig 16-22 → 16-26)

The internal capsule is simply represented by all the thalamocortical and corticothalamic projections we have been discussing throughout the course. It travels in the cleft between lenticular nucleus and thalamus (Fig 16-21 – good 3 dimensional representation).

What is the **corona radiata** (has nothing to do with oocyte boundaries – Fig 2.6 of Langman's Embryology!)? Fig 16-23 + 16-24 gives a good representation in the real brain. We know there are millions of fibres traversing the internal capsule to reach their destinations. The corona radiata is the portion just above the internal capsule – where fibres enter the internal capsule.

#### **Blood supply of internal capsule (Nolte 5<sup>th</sup> Ed pp 406, Netter Plate 133)**

The major blood supply to the internal capsule arises from **small branches** of the **middle cerebral artery** – known as – **lenticulostriate arteries**. The **anterior choroidal artery** – a slender branch travelling inferiorly – is another branch of the middle cerebral artery, also supplies the internal capsule.

#### **Parts of the internal capsule (Nolte 5<sup>th</sup> Ed pp 404, Fig 16-8/12)**

The internal capsule has five parts. The **anterior limb** is located between the lentiform nucleus and head of the caudate nucleus. The anterior limb consists of the following: interconnecting fibres between the anterior nucleus and cingulate gyrus, interconnecting fibres between dorsomedial nucleus and prefrontal cortex, also consists of small number of fibres projecting from frontal lobe → ipsilateral pontine nuclei (i.e.: frontopontine fibres).

The **posterior limb** is located between the lentiform nucleus and thalamus. It consists of the following: fibres interconnecting VA & VL with motor & premotor cortex, somatosensory fibres projecting from VPL/VPM of thalamus to primary somatosensory cortex, corticospinal & corticobulbar fibres.

The **genu** is the junction between the anterior + posterior limbs. It consists of the following: some frontopontine fibres, fibres interconnecting VA & VL with motor & premotor cortex, corticobulbar fibres.

In actuality fact the posterior limb leads to the **retrolenticular part** of the internal capsule, just posterior to the lentiform nucleus. The **sublenticular part** of the internal capsule is located just inferior to the lentiform nucleus (viewed in coronal section Fig 16-12). The retrolenticular part consists of the following: fibres connecting thalamus and parieto-occipital-temporal association cortex, part of the optic radiation (LGN → calcarine sulcus). The sublenticular part consists of the following: Meyer's loop, auditory radiation (MGN → transverse temporal gyrus (auditory cortex)).

#### **Cerebral cortex (Nolte 5<sup>th</sup> Ed pp 525)**

The cerebral cortex is split into two major areas. The **neocortex** is almost all of the cortex that can be seen from outside. The **allocortex** is composed of the limbic system and olfactory system. The neocortex is well developed in humans (getting bigger as we evolve) and contains approximately: **10-14 billion neurons**. Be aware that the neocortex can be represented by **lobes** or by **Brodmann's areas**.

#### **Neocortex contains pyramidal cells (Nolte 5<sup>th</sup> Ed pp 527)**

Almost all of the neurons of the neocortex are **pyramidal cells**, named for the shape of their cell body. These cells have a long apical dendrite (Fig 22-3) and a series of basal dendrites – from the base of the cell. The size of these neurons varies from 10um → 100um (giant pyramidal cells are called – **Betz cells**). The remaining cells of the neocortex are referred to as non-pyramidal cells (e.g.: granule cells).

#### **Histology of neocortex (Nolte 5<sup>th</sup> Ed pp 527, Fig 22-6)**

The cells of the neocortex are arranged into 6 layers (numbered using roman numerals – check names of layers). The outermost layer is the cell-poor molecular layer. The innermost layer is the polymorphic layer. The layers in between are composed of large Pyramidal cells and small cells. Different layers of the cortex are more prominent in different parts of the neocortex.

For example: In the motor cortex (which has neurons that give off long axons) → you see large pyramidal cells – lack of granule cells – so called agranular cortex. It lacks a prominent layer IV (internal granular layer). Another example: In the primary sensory cortex (which has

neurons that don't have long axons) → you see lots of granule cells – lack of pyramidal cells – so called granular cortex.

### **The Different Lobes of the Cerebral Cortex (Nolte 5<sup>th</sup> Ed pp 534-549)**

#### **Parietal Lobe (Nolte 5<sup>th</sup> Ed pp 536 Fig 22-16)**

The parietal lobe is located posterior to the central sulcus and superior to the lateral sulcus. It is to do with perception and discrimination of sensory stimuli. It contains the primary somatosensory cortex (postcentral gyrus), somatosensory association cortex (just posterior to post central gyrus). The parietal lobe also contains Wernicke's area: part of inferior parietal lobule (also part of superior temporal gyrus) – usually located in the left hemisphere.

#### **Temporal lobe (Nolte 5<sup>th</sup> Ed pp 540 Fig 22-16)**

The temporal lobe is largely associated with perception and discrimination of auditory stimuli. It contains the primary auditory cortex (superior temporal gyrus), auditory association cortex (right next to it), visual association area (inferior temporal gyrus).

#### **Occipital Lobe (Nolte 5<sup>th</sup> Ed pp 539 Fig 22-16)**

The occipital lobe is largely associated with perception of visual stimuli. It contains the primary visual cortex (Brodmann's area 17 – Fig 22-16), & visual association cortex (Brodmann's area 18, 19).

#### **Frontal Lobe (Nolte 5<sup>th</sup> Ed pp 541 Fig 22-16)**

The frontal lobe is largely associated with initiation & control of voluntary movement. It contains the primary motor cortex, premotor cortex (postural adjustment), supplementary motor cortex (planning of movement), Broca's area (part of inferior frontal gyrus – involved in motor aspects of speech production), prefrontal cortex (mood, personality, judgement, working memory – i.e.: memory you use for quick remembering). *Remember in lecture she put up a slide of a scan of a person's brain with rod in it – and how he survived & his mood, personality, judgement changed from that day on – Fig 22-25 Nolte 5<sup>th</sup> Ed pp 549.*

#### **Cortical White Matter (Nolte 5<sup>th</sup> Ed pp 531 Fig 22-10, 22-11)**

**Association bundles** are masses of white matter – that interconnect areas within each cerebral hemisphere. These bundles are: **superior longitudinal fasciculus (arcuate fasciculus)**, **superior (sub callosal) + inferior occipitofrontal fasciculi**, & **cingulum**.

The **arcuate fasciculus** is a span of fibres sweeping from the frontal lobe, over the insula, to more posterior portions of the hemisphere – fanning out to reach temporal, parietal, occipital lobes. This connects Broca's area → Wernicke's area. Any lesion produces **conduction aphasia**. The **superior occipitofrontal fasciculus (sub callosal fasciculus)** runs from the occipital lobe to the frontal lobe – almost parallel to the corpus callosum. The **inferior occipitofrontal fasciculus** passes below the insula from the frontal lobe – through the temporal lobe – to the occipital lobe. The **uncinate fasciculus** is the part which hooks around the lateral sulcus (connects orbito-frontal cortex → temporal lobe). The **cingulum fasciculus** is located in the cingulate gyrus and runs around in continuation with parahippocampal gyrus → nearly makes a circle.

#### **Commissures (Nolte 5<sup>th</sup> Ed pp 549)**

The **corpus callosum** is a bundle of axons, which interconnect the two cerebral hemispheres together. The **anterior commissure** connects middle and inferior temporal gyri. The **posterior commissure** is the area where the pretectal area projects bilaterally to Edinger-Westphal nucleus to elicit direct/consensual pupillary reflex (Fig 17-38 Nolte 5<sup>th</sup> Ed pp 446).

#### **Disconnection syndrome (Nolte 5<sup>th</sup> Ed pp 552)**

**Disconnection syndrome** is caused by lesions in the association bundles connecting the frontal and occipital lobe (occipitofrontal fasciculi). Disconnection syndrome is characterised by **pure word blindness**. The patient has **alexia** (cant read) without **agraphia** (means cant write – but in this case its “**without agraphia**”). This occurs as a result of a stroke involving posterior cerebral artery (left/right depends on which visual cortex affected – usually artery supplies ipsilateral visual cortex).

**Out of interest (Notes)**

Notice the asymmetry of the brain. Reception and expression of language – usually left. Emotional content of speech (i.e.: if speech is “funny” / “sarcastic” etc) – usually right. Spatial orientation – usually right parietal association cortex. So if you have right parietal damage – patient ignores things on his/her left side (*Remember that drawing she showed us where the patient ignores the left side of the drawing she was meant to draw. Also, if you are really keen – I will show you a place in the hospital where there hangs a picture painted by (I think) someone who had this problem – something similar anyway*).