Introduction and Overview of Neuroanatomy

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Neurone

- The basic structural and functional unit of the nervous system
- The functions:
  to receive and integrate incoming information from sensory receptors or other neurones and to transmit information to other neurones or effector organs
- Information is passed between neurones at specialised regions called synapses where the membranes of adjacent cells are in close apposition
Neuron
Neuroglial cells

- More numerous than nerve cells but have ancillary roles and are not directly involved in information processing.
- There are three main types of neuroglial cell
Type of Neuroglia

- Oligodendroglia (oligodendrocytes) which form the myelin sheath that many neuronal axons
- Astroglia (astrocyte) May form the blood brain barrier
- Microglia have phagocytic function when the nervous system is damaged
Nervous system

- Central nervous system
  1. Brain
  2. Spinal cord
- Peripheral nervous system
  1. cranial nerves
  2. spinal nerves
Autonomic Nervous System (ANS)

- Innervates visceral structure and is important in homeostasis of the internal environment.
- divided into two anatomically and functionally distinct parts, namely the **sympathetic** and **parasympathetic** divisions.
- ANS generally have opposing (antagonistic) effects on the structures that they innervate
Afferent Neurone, Efferent Neurone and Interneurone

- Nerve cells that carry information from peripheral receptors to the CNS → afferent neurones
- the information that they carry ultimately reaches a conscious level → sensory neurones
- Efferent neurones carry impulses away from the CNS and if they innervate skeletal muscle to cause movement → motor neurones
- The vast majority of neurones, however, are located entirely within the CNS → interneurones
Afferent neurone, efferent neurone and interneurone
Grey and White Matter of CNS

- Some regions are relatively enriched in nerve cell bodies (e.g. the central portion of the spinal cord and the surface of the cerebral hemisphere) and are referred to as **grey matter**.
- Other regions contain mostly nerve processes (usually axons). These are often myelinated (ensheathed in myelin), which confers a paler coloration - hence the term **white matter**.
Grey and White matter of CNS
The process of formation of the embryonic nervous system is referred to as neurulation.

During the third week of embryonic development, the dorsal midline ectoderm undergoes thickening to form the neural plate.

The lateral margins of the neural plate become elevated, forming neural folds on either side of a longitudinal, midline depression, the neural groove.

The neural folds then become apposed and fuse together, thus sealing the neural groove and creating the neural tube.
Development of the CNS

(A) Shaping

(B) Folding

(C) Elevation

(D) Convergence

(4) Closure
Week 4
Neural Tube: Cell Growth and Differentiation

- Roof plate
- Alar plate
- Sulcus limitans
- Basal plate
- Marginal layer
- Mantle layer
- Ependymal layer
- Floor plate
Development of the brain

Primary brain vesicle (4-5 weeks)

Secondary brain vesicle (7-8 weeks)
**Forebrain**
- Diencephalon
- Telencephalon (cerebral vesicles)
- Optic stalk

**Midbrain**
- Mesencephalon
- Pontine flexure

**Hindbrain**
- Metencephalon
- Myelencephalon
- Spinal cord
Central Nervous system (brain)

- Procencephalon (forebrain):
  - Telencephalon → hemisphere
  - Diencephalon → thalamus, hypothalamus, metathalamus, subthalamus, hypothalamus.
- Mesencephalon (midbrain)
- Rhombencephalon (hindbrain)
  - Metencephalon → pons, cerebellum
  - Myelencephalon → Medulla oblongata
Coverings and blood supply of the CNS

- The brain and spinal cord are invested by three meningeal layers: the dura mater, arachnoid mater and pia mater
- Two sheets of cranial dura mater, the falx cerebri and tentorium cerebelli, incompletely divide the cranial cavity into compartments
- The cranial dura mater contains dural venous sinuses, which act as channels for the venous drainage of the brain
- Beneath the arachnoid mater lies the subarachnoid space in which cerebrospinal fluid (CSF) circulates
- The spinal cord is supplied by vessels arising from the vertebral arteries, reinforced by radicular arteries derived from segmental vessels
Anatomy of the spinal cord

- The spinal cord lies within the vertebral canal. It bears 31 pairs of spinal nerves through which it receives fibres from, and sends fibres to, the periphery.
- Near the cord, spinal nerves divide to form dorsal and ventral roots.
  - Dorsal roots, carry afferent fibres with cell bodies in dorsal root ganglia.
  - Ventral roots, carry efferent fibres.
- The spinal cord consists of:
  - Central core of grey matter, containing nerve cell bodies.
  - Outer layer of white matter or nerve fibres.
Anatomy of the spinal cord (cont....)

- Grey matter:
  - dorsal horn → sensory neurones
  - ventral horn → motor neurones
  - lateral horn → preganglionic sympathetic neurones
- The principal ascending tracts:
  - dorsal columns
  - spinothalamic tracts
  - spinocerebellar tract
- The important descending tract:
  - corticospinal tract
Medulla spinalis

- Lateral corticospinal tract
- Anterior corticospinal tract
- Dorsal columns
- Spinothalamic tract
Anatomy of the brain

- The brain:
  1. forebrain
     - cerebral hemisphere
     - diencephalon (thalamus and hypothalamus)
  2. midbrain
     - mesencephalon
  3. hindbrain
     - cerebellum
     - pons
     - medulla oblongata
- The medulla, pons and mesencephalon → brain stem
Cerebellum

Sagittal section

- Anterior lobe
- Cerebellar cortex
- Medulla oblongata
- Flocculonodular lobe
- Posterior lobe

- Hemispere
- Vermis
- Primary Fissure
- Horizontal Fissure
- Posterior Fissure
- Flocculus
- Nodulus
- Anterior Lobe
- Posterior Lobe
Anatomy of the brain

- Within the cerebral hemisphere lie several large nuclei: basal ganglia or corpus striatum.
- The brain contains a system of cavities or ventricles containing CSF, which is produced by the choroid plexus.
- The brain possesses 12 pairs of cranial nerves, which carry afferent and efferent fibres.
- The two cerebral hemispheres are linked by the fibres of the corpus callosum.
Ganglia basalis
Ventricular system
Cranial nerves

- **Sensory fibres**
- **Motor fibres**

**Optic (II)**
- **Sensory**: eye

**Trochlear (IV)**
- **Motor**: superior oblique muscle

**Abducent (VI)**
- **Motor**: external rectus muscle

**Oculomotor (III)**
- **Motor**: all eye muscles except those supplied by IV and VI

**Trigeminal (V)**
- **Sensory**: face, sinuses, teeth, etc.
- **Motor**: muscles of mastication

**Facial (VII)**
- **Motor**: muscles of the face

**Intermediate nerve**
- **Sensory**: anterior part of tongue and soft palate

**Vestibulocochlear (VIII)**
- **Sensory**: inner ear
- **Vestibular**
- **Cochlear**

**Glossopharyngeal (IX)**
- **Motor**: pharyngeal musculature
- **Sensory**: posterior part of tongue, tonsil, pharynx

**Vagus (X)**
- **Motor**: heart, lungs, bronchi, gastrointestinal tract
- **Sensory**: heart, lungs, bronchi, trachea, larynx, pharynx, gastrointestinal tract, external ear

**Hypoglossal (XII)**
- **Motor**: muscles of the tongue

**Accessory (XI)**
- **Motor**: sternocleidomastoid and trapezius muscles

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Corpus callosum
Basic clinical diagnostic principles

- History-taking, clinical examination and investigations lead to the diagnosis of the cause (aetiology) of disease
- The site of the lesion(s) determines the clinical syndrome revealed by the neurological examination
- Disorders of the nervous system can be classified as intrinsic, extrinsic, systemic, or vascular
Intrinsic disorders

- primary disorders of the nervous system itself
- Intrinsic disorders consist of system degenerations (atrophy), inborn errors of metabolism, paroxysmal disorders, neoplasms, infections and immune disorders
- Examples:
  1. consciousness (epilepsy),
  2. excessive sleep (narcolepsy)
  3. headache (migraine)
  4. Muscular dystrophies
  5. Hereditary sensorimotor neuropathies
  6. Hereditary spastic paraparesis
  7. Cerebelar ataxias and Huntington’s disease.
Extrinsic disorders

Extrinsic disorders lead to compression of the brain, spinal cord, nerve roots and peripheral nerves.

The brain may be compressed on its outer surface by blood clots (haematomas), abscesses and tumours.

Fluid-filled ventricles may compress the brain (hydrocephalus).

The spinal cord may be compressed by disease of the spine, such as arthritis (spondylosis), meningiomas.
Systemic disorders

- primarily disorders of organs other than the nervous system that disrupt neuromuscular function by abnormal metabolism
- Examples:
  failure of the cardiorespiratory system, liver or kidneys, or hormonal (endocrine) disorders such as thyroid disease, diabetes mellitus and abnormalities in calcium and potassium balance
Vascular disorders

- Occlusion of the vessels (thrombosis)
- Restriction of the blood and oxygen supply (infarction)
- Bleeding into the nervous tissues (haemorrhage)
Lower motor neuron (LMN) syndrome

- Weakness (paresis) or paralysis (plegia) of individual muscles
- Wasting of muscles
- Visible spontaneous contractions of motor units (fasciculation)
- Reduced resistance to passive stretching (hypotonia)
- Diminution or loss of deep tendon reflexes (hyporeflexia or areflexia).
Upper motor neurone (UMN) syndrome

- Weakness or paralysis of specific movements (extension of the upper limbs and flexion of the lower limbs, termed ‘pyramidal weakness’)
- No wasting of muscles
- Increased resistance to passive stretching of muscles (spasticity); initial resistance to muscular stretching followed by relaxation (clasp-knife response)
- Hyperactivity of deep tendon reflexes (hyperreflexia)
- Emergence of the extensor plantar response (positif Babinski reflex) leading to dorsiflexion of the great toe on stimulation of the sole of the foot
- Loss of abdominal reflexes.
Disorders of the cerebellum

Cerebellum is concerned with the coordination of movement

Cerebellar lesions cause:

- Nystagmus
- Dysarthria (scanning speech)
- Intention tremor
- Ataxia

The signs and symptoms occur ipsilateral to the lesion
Disorder of the Basal Ganglia

Basal ganglia lesion cause:

- Slow initiation and execution of movement (akinesia)
- Increased muscular tone (rigidity)
- Abnormal involuntary movements (dyskinesias)

The sign and symptoms occur contralateral to the lesion.
Neuropsychological Functions
Neuropsychological Functions

- Executive function
- Frontal lobe syndrome
- Praxis
- Apraxia
- Perceptuospatial function
- Agnosia
- Spatial disorientation
- Language
  - Aphasia
  - Alexia
  - Agraphia
  - Acalculia
- Memory
- Amnesia
Investigations of Neuromuscular Disease

The major focus of investigations involves:

- CSF analysis
- Neuroradiology
- Neurophysiology
- Neuropathology (biopsy)
Computed Tomography (CT)
Magnetic Resonance Imaging (MRI)
Carotid angiogram