SAWA UNIVERSITY

تشريح الشعاعي و الكورس الأول

NORMAL ANATOMY AND RADIOLOGICAL FEATURES OF THE BASAL GANGLIA

Sawa University — جامعـــــة ســـــــاوة الاهلية

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Third Stage — المرحلـــــــــــة الثالثة

محاضرة رقم 7

Lecture No. …7.

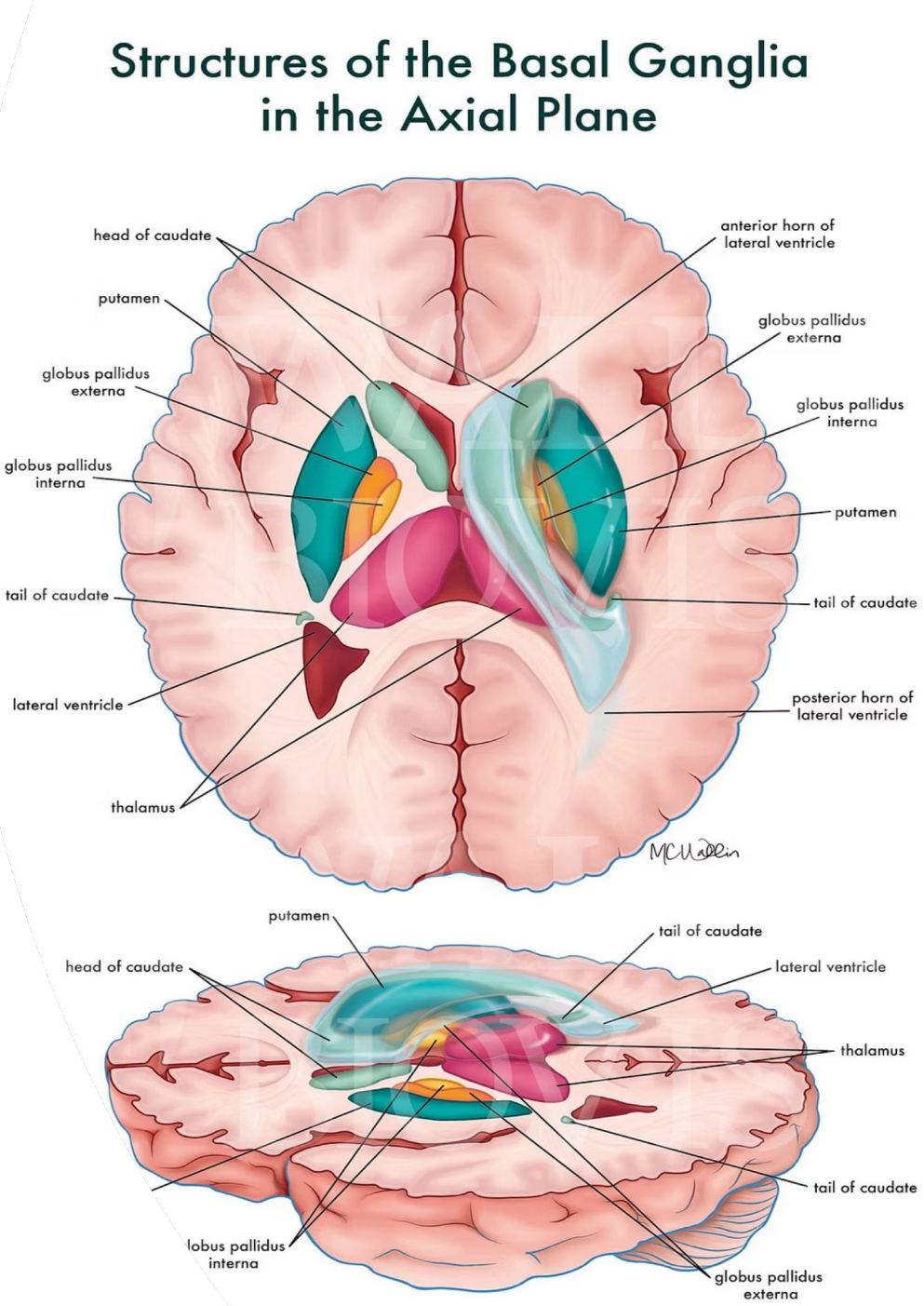
الجانب النظري

Theoretical

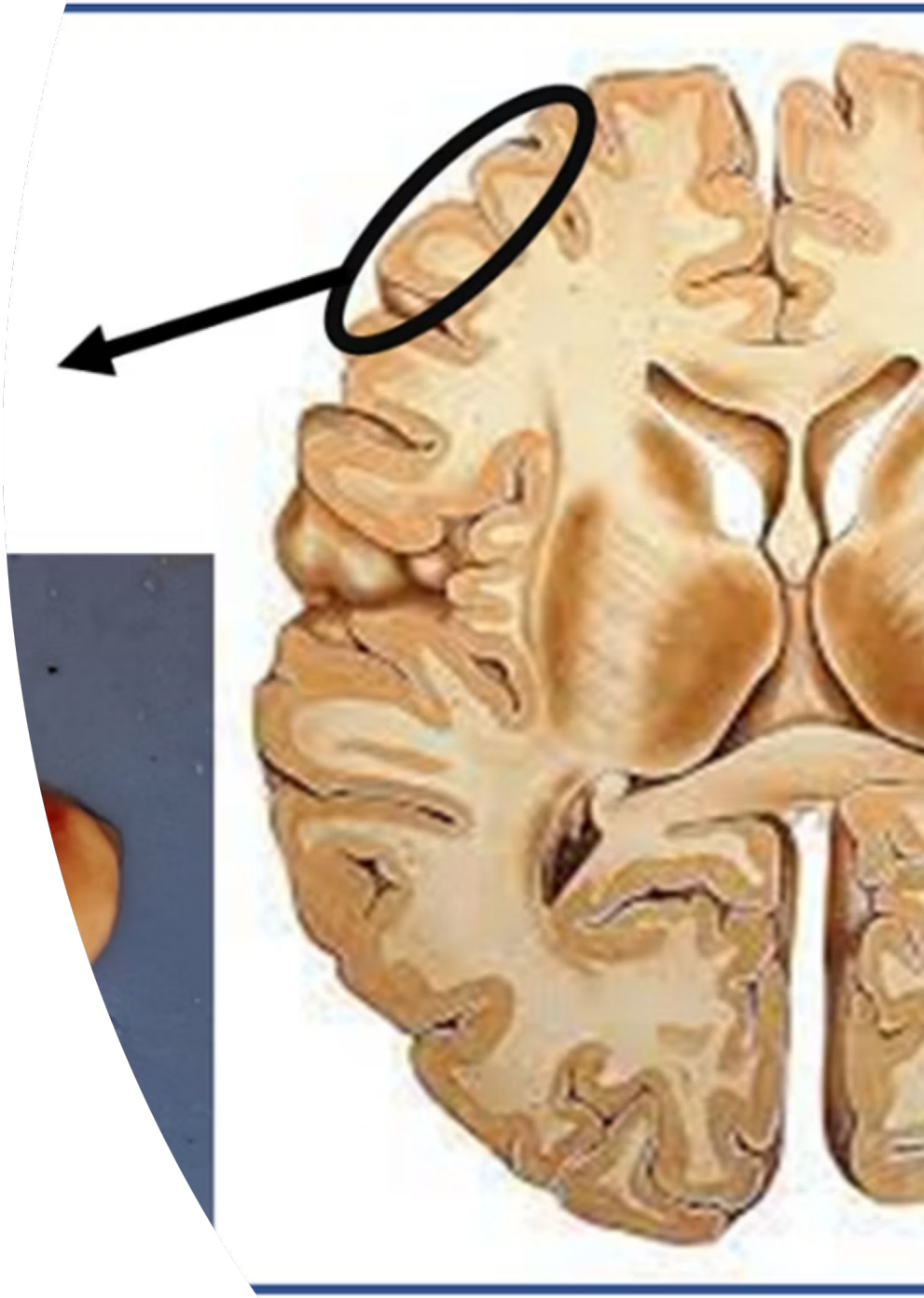
تدريسي المادة : م.م.ابراهيم فاضل

Normal Anatomy and Radiological Features of the Basal Ganglia

A comprehensive exploration of deep brain nuclei structure, function, and imaging characteristics

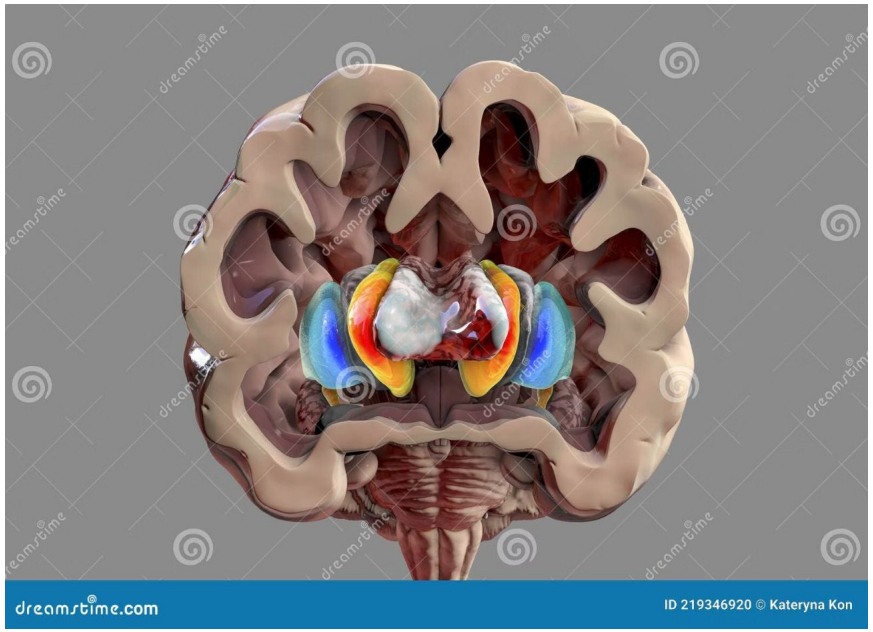


Understanding the Basal Ganglia – Anatomy Overview



What Are the Basal Ganglia?

The basal ganglia represent a collection of subcortical nuclei comprising deep grey matter structures within the cerebral hemispheres. These highly interconnected nuclei form complex circuits with the cerebral cortex, thalami, and brainstem structures.



Despite their historical name, these structures are technically termed **"basal nuclei"** rather than ganglia, as true ganglia exist only in the peripheral nervous system, whilst these nuclei reside within the central nervous system.

These remarkable structures orchestrate essential functions including voluntary motor control, procedural learning, cognitive processes, emotional regulation, and reward-based behaviour.

WHAT ARE THE BASAL GANGLIA?

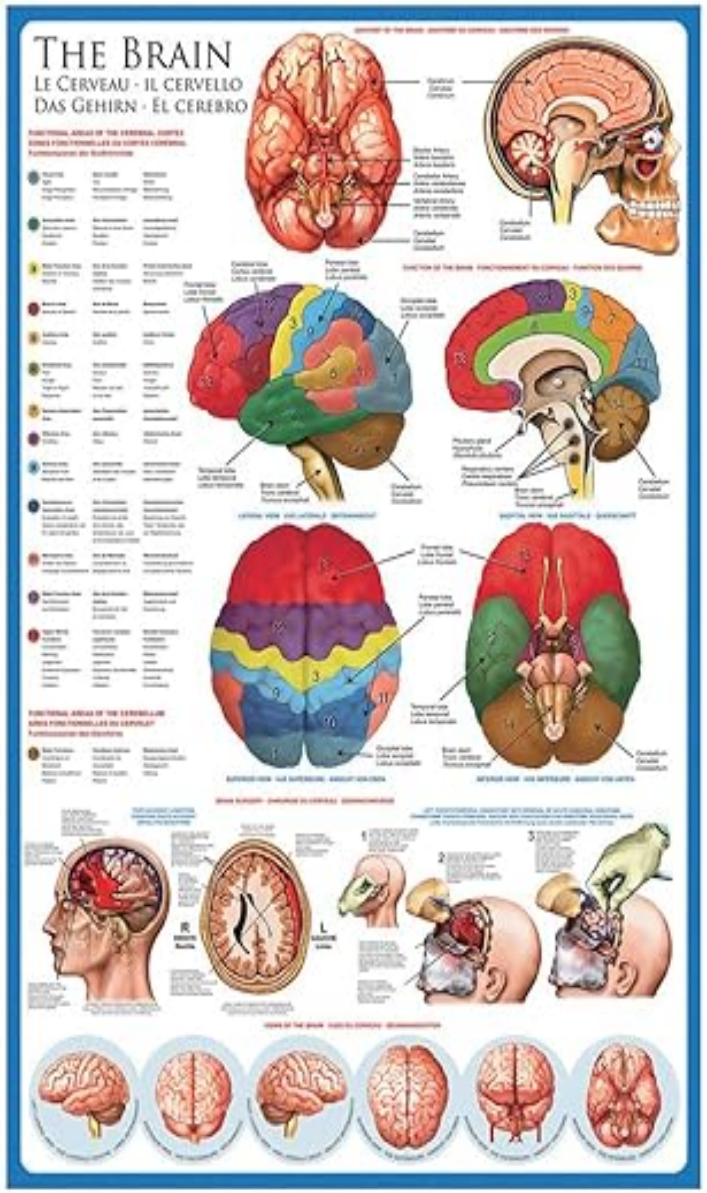
- • A group of deep brain structures
- • Responsible for movement control
- • Play roles in emotion, learning, and habits

MAIN COMPONENTS

- • Caudate Nucleus
- • Putamen
- • Globus Pallidus
- • Substantia Nigra
- • Subthalamic Nucleus

FUNCTIONS

- • Initiation of movement
- • Stopping movement
- • Regulation of movement intensity
- • Coordination of complex movements
- • Motor learning and habit formation
- • Involvement in reward and motivation



Functional Anatomy Highlights

1

Striatum (Caudate + Putamen)

Principal input centre receiving excitatory glutamatergic projections from widespread cortical areas. Contains medium spiny neurons that initiate basal ganglia processing.

2

Globus Pallidus

Main output nuclei divided into internal (GPi) and external (GPe) segments. GPi projects to thalamus, completing motor and cognitive loops back to cortex.

3

Subthalamic Nucleus

Unique excitatory glutamatergic nucleus providing crucial modulation to globus pallidus. Essential for fine motor control and impulse regulation.

4

Substantia Nigra

Divided into pars compacta (dopaminergic neurons) and pars reticulata. Dopamine release modulates striatal activity, critical for movement initiation and motivation.

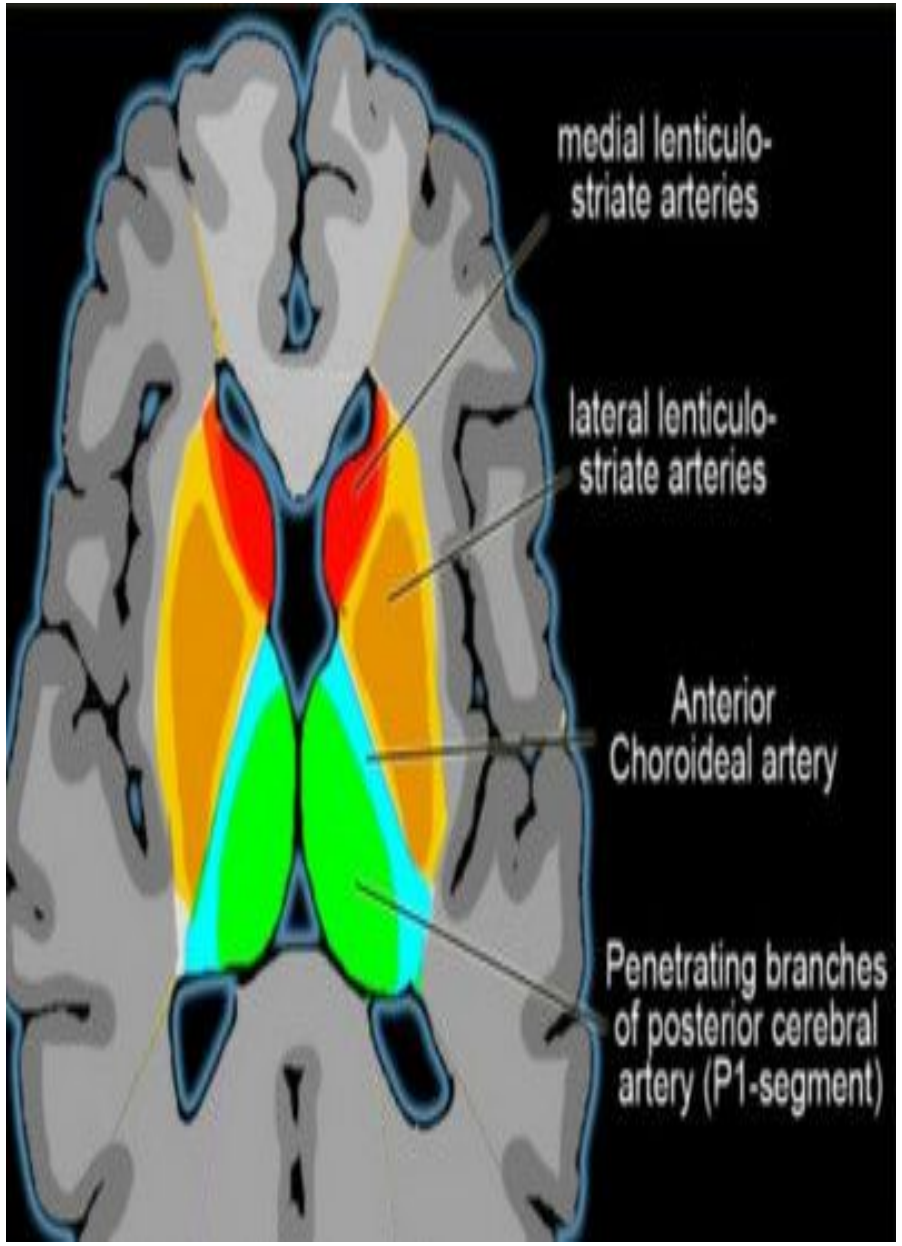
Radiological Appearance on CT and Ultrasound

Computed Tomography (CT)

Basal ganglia structures appear isodense to cerebral cortex on non-contrast CT. The lentiform nucleus is clearly delineated from the caudate by the internal capsule. Physiological calcifications, particularly in the globus pallidus, may cause subtle hyperdensity, especially in elderly patients.

Cranial Ultrasound (Neonatal)

Through the anterior fontanelle, basal ganglia appear isoechoic to normal brain parenchyma. The thalami and lentiform nuclei are well visualised. Increased echogenicity suggests pathology including oedema, ischaemia, haemorrhage, or metabolic derangement requiring urgent investigation.



MRI Signal Characteristics of Basal Ganglia

T1-Weighted Imaging

Basal ganglia structures typically appear isointense to cortex. The globus pallidus frequently demonstrates slightly increased T1 signal intensity due to physiological myelin content and trace mineral deposition, particularly iron and calcium.

T2-Weighted & FLAIR

Generally isointense to cortex with notable exceptions. Iron accumulation, particularly prominent in the globus pallidus and putamen, causes characteristic T2 and FLAIR hypointensity that progressively increases with advancing age.

Susceptibility-Weighted Imaging

Highly sensitive to paramagnetic substances including iron and calcium. Demonstrates pronounced signal loss in iron-rich structures. When calcification exceeds 30% of tissue volume, marked signal void occurs across all sequences.

Clinical Relevance: Imaging in Basal Ganglia Disorders

Parkinson's Disease

Progressive degeneration of dopaminergic neurons in the substantia nigra pars compacta. Conventional MRI may appear normal early in disease. Advanced sequences including neuromelanin-sensitive imaging and susceptibility-weighted imaging can demonstrate substantia nigra signal changes and volume loss.

Huntington's Disease

Characteristic atrophy predominantly affecting the caudate nucleus head and putamen, resulting in enlargement of the frontal horns of lateral ventricles ("boxcar ventricles"). T2 hyperintensity may accompany atrophy. Progressive volume loss correlates with clinical severity.

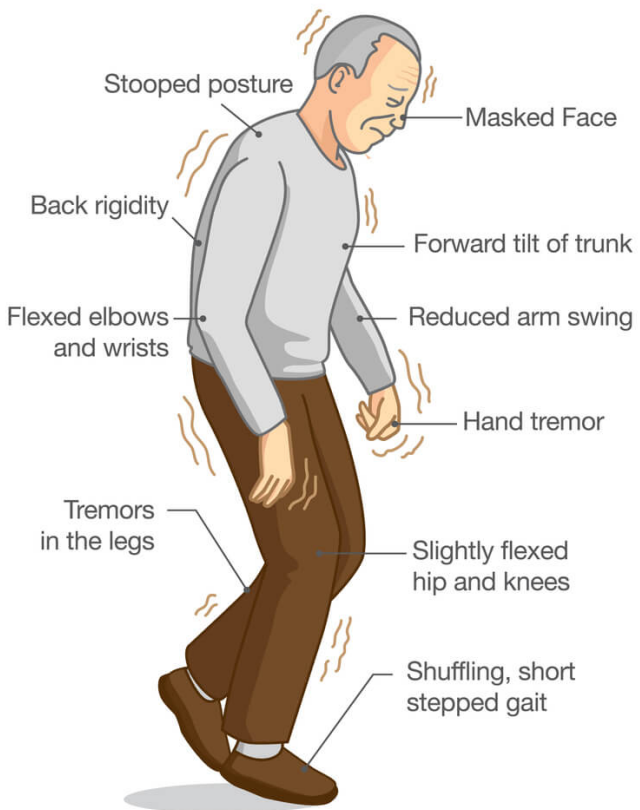
Metabolic & Toxic Disorders

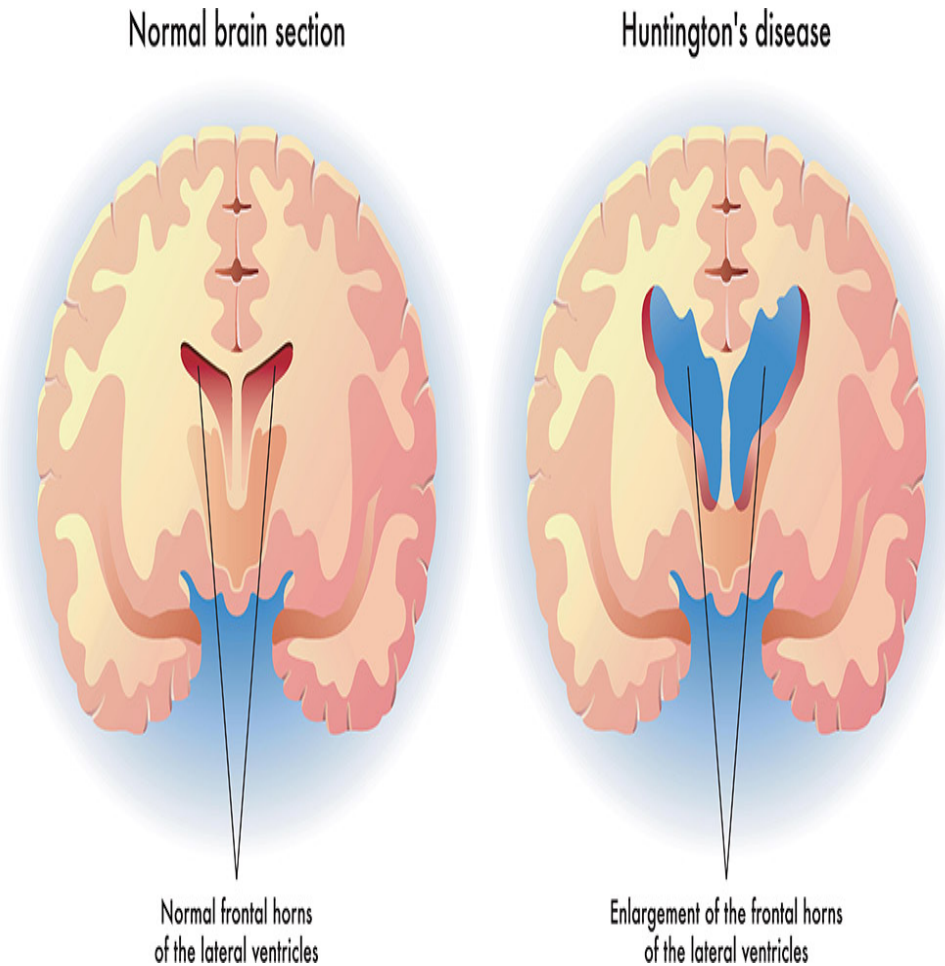
Bilateral basal ganglia calcifications visible on CT suggest metabolic conditions (hypoparathyroidism, Fahr's disease). Toxic exposures (carbon monoxide, methanol, cyanide) produce characteristic bilateral globus pallidus necrosis with T2 hyperintensity.

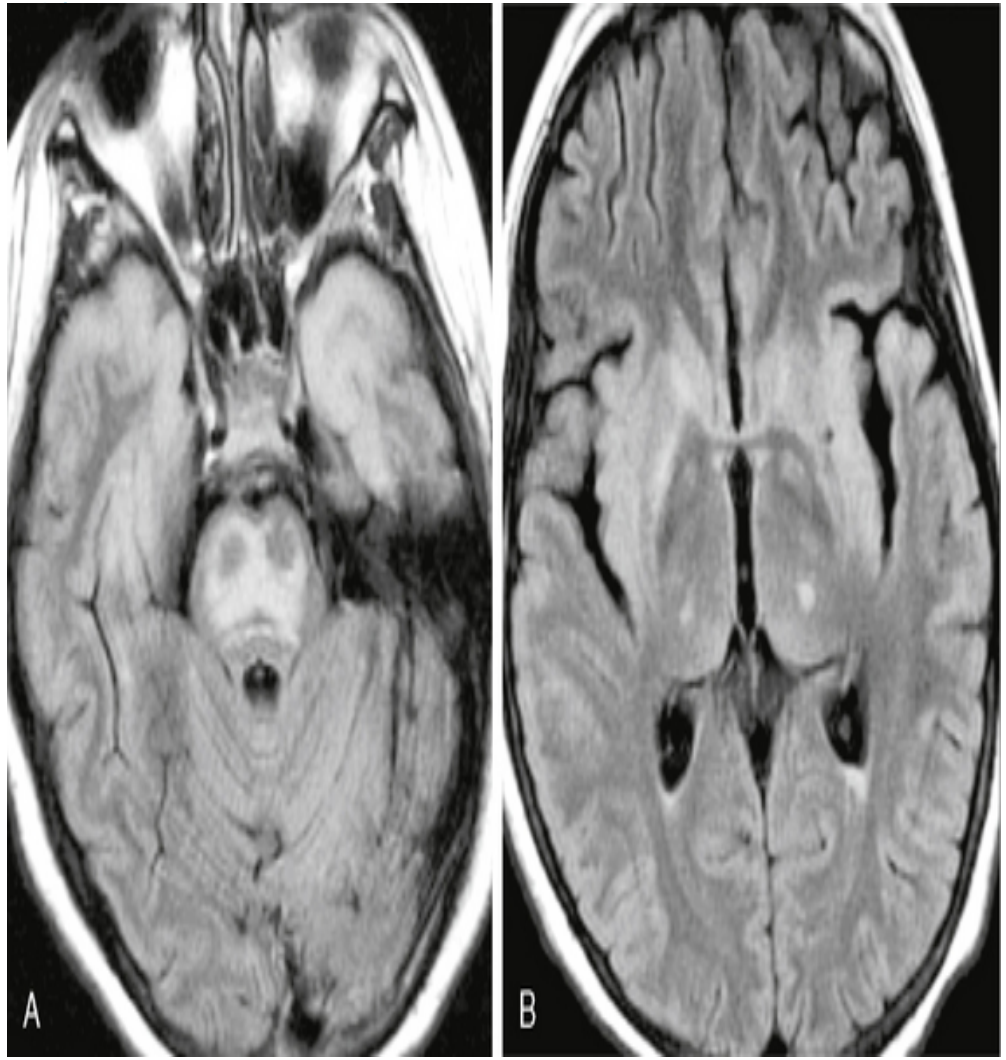
Ischaemic & Haemorrhagic Lesions

Lacunar infarcts commonly affect basal ganglia due to small vessel disease. Hypertensive haemorrhage has predilection for putamen and thalamus. CT remains excellent for acute haemorrhage detection, whilst MRI provides superior characterisation of chronic changes.

Parkinson's Disease Symptoms



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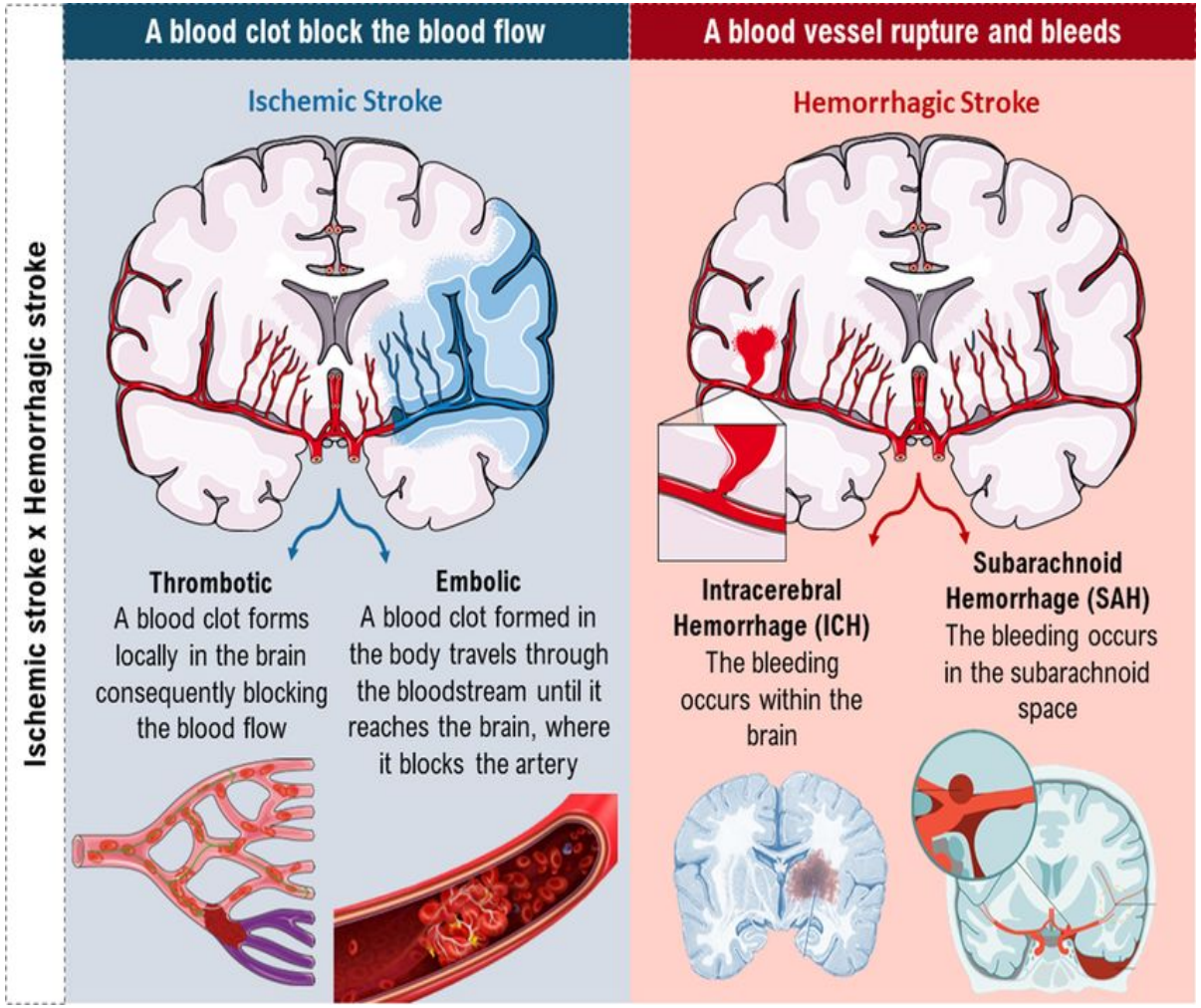
Ischemic stroke x Hemorrhagic stroke
A blood clot block the blood flow
A blood vessel rupture and bleeds
Ischemic Stroke
Hemorrhagic Stroke
Thrombotic
A blood clot forms locally in the brain consequently blocking the blood flow
Embolic
A blood clot formed in the body travels through the bloodstream until it reaches the brain, where it blocks the artery
Intracerebral Hemorrhage (ICH)
The bleeding occurs within the brain
Subarachnoid Hemorrhage (SAH)
The bleeding occurs in the subarachnoid space

Summary: Key Takeaways

Complex Anatomical Architecture

The basal ganglia comprise interconnected deep grey matter nuclei essential for motor control, cognitive processing, emotional regulation, and reward-based learning. Understanding their intricate anatomy and circuitry is fundamental to clinical practice.

Characteristic Imaging Features

Each imaging modality (CT, ultrasound, MRI) reveals distinct characteristics of basal ganglia structures. Recognition of normal appearances, age-related changes, and physiological variants prevents misinterpretation as pathology.

Clinical Diagnostic Importance

Comprehensive knowledge of normal anatomy and imaging features enables accurate detection and characterisation of basal ganglia pathology, including neurodegenerative, vascular, metabolic, and toxic conditions affecting these critical structures.

Advancing Technology

Continued developments in MRI techniques, including high-field imaging, advanced diffusion methods, and quantitative susceptibility mapping, progressively enhance our ability to detect subtle basal ganglia abnormalities earlier in disease processes.

QUIZ

Any questions?