



RU RMT 16 — NEUROLOGY 2

Lecture 7

Neuroanatomy & Pathophysiology of the Brain

Brainstem · Cerebellum · Diencephalon · Cerebrum · Brain Injuries

Ruhani College of Massage Therapy

Massage Therapy Diploma Program · Course: RU RMT 16 — Neurology 2

Prepared in accordance with CMTCA inter-jurisdictional competency and standards of practice.



By the end of this lecture, the student will be able to:

- Describe the structure and function of the brainstem, cerebellum, diencephalon, and cerebrum.
- Explain how motor and sensory pathways cross (decussate), producing contralateral clinical presentations.
- Identify the autonomic and limbic structures that underlie the relaxation response elicited by massage.
- Recognize neurological signs — such as ataxia or altered consciousness — that inform assessment and treatment adaptation.
- Identify red flags of acquired brain injury and hematoma that require emergency referral and are contraindications to massage.
- Apply this knowledge safely and appropriately within the RMT scope of practice.



SECTION 1

The Brainstem

Midbrain, pons, and medulla oblongata — the conduit between brain and body and the seat of vital, involuntary control.



Brainstem — Overview

- Connects the cerebrum and diencephalon to the spinal cord; a conduit for all ascending (sensory) and descending (motor) tracts.
- Three regions from superior to inferior: midbrain, pons, and medulla oblongata.
- Contains the nuclei of cranial nerves III–XII.
- Houses centres that control vital, involuntary functions (cardiac, respiratory, reflexes).
- The reticular formation runs through all three regions.

Clinical relevance for RMTs The brainstem governs the autonomic and arousal responses that massage can influence, and lies deep to the suboccipital region — a common area of treatment.



Medulla Oblongata — Motor Pathways

- The inferior part of the brainstem, continuous with the spinal cord; carries all ascending and descending white-matter tracts.
- The anterior bulges — the pyramids — carry the descending corticospinal (pyramidal) tracts for voluntary motor control of the trunk and limbs.
- Decussation of the pyramids: about 90% of corticospinal fibres cross to the opposite side in the inferior medulla.
- Result: each cerebral hemisphere controls the contralateral (opposite) side of the body.

Clinical relevance for RMTs A lesion above the decussation (e.g., a stroke) causes weakness on the opposite side of the body — the anatomical basis for interpreting hemiparesis.



Medulla Oblongata — Vital Centres & Nuclei

- Cardiovascular centre — regulates heart rate and stroke volume.
- Respiratory centre — regulates the rate and depth of breathing.
- Autonomic reflex centres — vomiting, swallowing (deglutition), peristalsis, sneezing, and coughing.
- Relay nuclei — gracilis & cuneatus (touch, pressure, vibration, proprioception) and the inferior olivary nucleus (motor coordination).
- Cranial-nerve nuclei — IX Glossopharyngeal, X Vagus, XI Accessory, XII Hypoglossal.

Clinical relevance for RMTs Vagal (parasympathetic) activity from the medulla underlies the 'rest-and-digest' relaxation response that therapeutic massage promotes.

Pons

- Sits between the midbrain and medulla, anterior to the cerebellum.
- Pontine nuclei — relay information between the cerebrum and cerebellum for coordinated movement.
- Vestibular nuclei — integrate information from the inner ear (balance) and the cerebellum.
- Pneumotaxic and apneustic centres — fine-tune breathing together with the medullary respiratory centre.
- Cranial-nerve nuclei — V Trigeminal, VI Abducens, VII Facial, VIII Vestibulocochlear.

Clinical relevance for RMTs The trigeminal (V) and facial (VII) nuclei are relevant to head, face, and TMJ work, and to conditions such as Bell's palsy.

Midbrain

- Found between the pons and the diencephalon; the cerebral aqueduct passes through it, connecting the 3rd and 4th ventricles for CSF flow.
- Cerebral peduncles (anterior) — white-matter tracts carrying mainly motor information from cerebrum → pons → medulla.
- Corpora quadrigemina (posterior) — superior colliculi (visual reflexes of eyes/head/trunk) and inferior colliculi (auditory reflexes).
- Substantia nigra — releases dopamine to the basal ganglia to modify movement; its degeneration leads to Parkinson's disease.
- Red nucleus (coordinates neck & eye muscles); cranial-nerve nuclei III Oculomotor and IV Trochlear.

Clinical relevance for RMTs Loss of substantia-nigra dopamine underlies Parkinsonian rigidity, resting tremor, and bradykinesia — adapt positioning, pacing, and pressure accordingly.



Reticular Formation & the RAS

- A network of interconnected neurons spanning all three brainstem regions (midbrain, pons, medulla).
- The Reticular Activating System (RAS) projects to the cerebrum to regulate attention, alertness, arousal, and the sleep–wake cycle.
- Also helps maintain posture and muscle tone.
- Damage can result in a reduced level of consciousness or coma.

Clinical relevance for RMTs Massage can down-regulate arousal through the RAS, supporting relaxation and sleep. A falling level of consciousness is a red flag requiring urgent care.



SECTION 2

The Cerebellum

The coordinator of movement — refining, timing, and balancing the motor commands initiated by the cerebral cortex.



Cerebellum — Structure & Function

- Primary function: to regulate, coordinate, and fine-tune movement — it does not initiate movement itself.
- Located inferior to the cerebrum and posterior to the brainstem; separated from the cerebrum by the tentorium cerebelli (dura) in the transverse fissure.
- Surface folds are called folia (they increase surface area); the central vermis divides the two cerebellar hemispheres.
- Grey-matter cortex overlies white matter (the 'arbor vitae'); deep cerebellar nuclei communicate with the cerebrum and brainstem.
- Also contributes to balance, posture, and motor learning.

Clinical relevance for RMTs Cerebellar dysfunction presents as poor coordination and balance — screen for fall risk and adapt handling, transfers, and positioning.



Cerebellar Peduncles

- Peduncles are the white-matter (axonal) connections between the cerebellum and the brainstem.
- Superior cerebellar peduncle — mainly output: cerebellum → midbrain and thalamus.
- Middle cerebellar peduncle — input: brings information to the cerebellum from the pons.
- Inferior cerebellar peduncle — mainly sensory input from the medulla and spinal cord.
- Together they let the cerebellum compare intended movement with actual movement.

Clinical relevance for RMTs Proprioceptive input generated by massage, stretching, and mobilization reaches the cerebellum through these pathways, supporting coordination.



Cerebellar Ataxia

- Ataxia means 'without order' — a disruption of muscle coordination.
- Signs: a staggering, wide-based ('drunken') gait, intention tremor, and slurred or scanning speech (dysarthria).
- Triggered by damage or disease of the cerebellum.
- Causes include infarction, infection, tumour, autoimmune disease (e.g., MS), trauma, and toxins.

Clinical relevance for RMTs Recognize ataxia during gait and observation; ensure safe transfers and positioning. New or worsening ataxia — or any undiagnosed neurological sign — warrants referral.



SECTION 3

The Diencephalon

The relay and regulatory hub — the thalamus, hypothalamus, and epithalamus surrounding the third ventricle.



Diencephalon — Overview

- Sits within the cerebrum, above the brainstem, surrounding the third ventricle.
- Three main components: the thalamus, the hypothalamus, and the epithalamus.
- Also includes the circumventricular organs.
- Functions as the relay and regulatory link between higher brain centres and the body.

Thalamus

- The largest part of the diencephalon; a paired structure made mostly of grey matter.
- Primary function as an information relay station, with reciprocal connections to almost all brain areas, the cerebellum, brainstem, and spinal cord.
- Relays sensory information (e.g., touch) from the spinal cord to the appropriate area of the cerebral cortex — all senses except smell.
- Relays motor information from the basal ganglia and cerebellum to the primary and premotor cortices.
- Specialized nuclei relay auditory (medial geniculate), visual (lateral geniculate), and limbic-system information.

Clinical relevance for RMTs Thalamic lesions can cause altered sensation or central ('thalamic') pain — interpret abnormal sensory findings cautiously and avoid areas of impaired sensation.



Hypothalamus

- Located anterior and inferior to the thalamus.
- Maintains homeostasis by controlling the autonomic nervous system (ANS) and the endocrine system (specifically the pituitary gland).
- Via the ANS: regulates heart rate, blood pressure, sweating, GI peristalsis, and body temperature.
- Via pituitary hormones: influences blood pressure, ovulation, libido, energy mobilization, and growth.
- Also governs hunger, thirst, and circadian timing.

Clinical relevance for RMTs Massage shifts autonomic balance toward parasympathetic dominance (lower heart rate and blood pressure) — the physiological basis of the relaxation response.



Epithalamus — Pineal Gland & Habenula

- Located at the posterior of the thalamus, with two main parts: the pineal gland and the habenula.
- Pineal gland — secretes the hormone melatonin, released in anticipation of and in response to darkness.
- Melatonin release contributes to the regulation of circadian (sleep–wake) rhythms.
- Habenula — function not clearly defined; suggested roles in the emotional response to smell and in processing pain and reward.

Clinical relevance for RMTs Supporting healthy sleep and circadian rhythm is a recognized benefit of relaxation-focused massage.



Circumventricular Organs & the Blood–Brain Barrier

- The blood–brain barrier (BBB) protects neural tissue by tightly controlling what crosses from the blood into the brain.
- Circumventricular organs are parts of the brain that are not protected by the BBB.
- Without the BBB, they can better monitor the chemical composition of systemic blood.
- They can also secrete hormones into the blood with ease (e.g., the pituitary gland).

Clinical relevance for RMTs The BBB limits which drugs and substances reach the CNS — useful context when a client reports CNS-active medications during history-taking.



SECTION 4

The Cerebrum

The largest part of the brain — the seat of voluntary movement, sensation, language, emotion, learning, and memory.



Cerebrum — Overview & Functions

- The largest part of the brain and the seat of higher functions.
- Functions: voluntary movement, personality, language and communication, problem solving, emotion, and learning & memory.
- The outer cortex is grey matter; deep to it lies sub-cortical white matter.
- In development, the grey-matter cortex grows faster than the white matter, leading to folding that greatly increases surface area.



Folds, Fissures & the Corpus Callosum

- Gyrus — an outward fold of cortex. Sulcus — a shallow groove between gyri. Fissure — a deep groove separating brain components.
- The most prominent fissure, the longitudinal fissure, separates the left and right cerebral hemispheres.
- The hemispheres are not completely separate — they are connected by the corpus callosum.
- The corpus callosum is a thick band of white matter (commissural fibres) that allows the two hemispheres to communicate.



Cerebral Lobes

- The cerebrum has five lobes, mostly named for the cranial bones that cover them:
 - Frontal — voluntary movement, personality, executive function, expressive speech.
 - Parietal — somatosensation and spatial awareness.
 - Temporal — hearing, memory, and language comprehension.
 - Occipital — vision.
 - Insular (insula) — deep to the lateral sulcus; interoception and autonomic/visceral processing.
- Landmarks: central sulcus (frontal/parietal), lateral sulcus (temporal), parieto-occipital sulcus (parietal/occipital).



Motor & Somatosensory Cortex

- Precentral gyrus — immediately anterior to the central sulcus; this is the primary motor cortex, which initiates voluntary movement of the contralateral body.
- Postcentral gyrus — immediately posterior to the central sulcus; this is the primary somatosensory area, receiving touch, pressure, and proprioception from the contralateral body.
- Both are somatotopically mapped — the 'homunculus.'
- Because pathways cross, cortical lesions produce deficits on the opposite side of the body.

Clinical relevance for RMTs Localized weakness or sensory change maps to specific cortical regions; a contralateral pattern reflects crossing pathways. Document and refer any new deficit.



Sub-Cortical White Matter

- There are three categories of white-matter tracts in the brain:
 - Association fibres — connect gyri (grey-matter areas) within the same cerebral hemisphere.
 - Commissural fibres — connect one hemisphere to the other (e.g., corpus callosum, anterior/posterior commissures).
 - Projection fibres — connect the cerebrum to other parts of the CNS (diencephalon, brainstem, spinal cord, cerebellum).
- The internal capsule is the most prominent projection tract.

Clinical relevance for RMTs The internal capsule carries dense motor and sensory projection fibres; even a small lesion here can cause significant contralateral deficits.

Basal Ganglia

- Collections of grey matter deep within the cerebrum of each hemisphere (e.g., caudate, putamen, globus pallidus; linked to the substantia nigra and subthalamic nucleus).
- Help initiate and terminate movement, inhibit unwanted movement, and promote or enhance desired movement — regulating muscle tone and smooth motion.
- Dysfunction underlies movement disorders such as Parkinson's disease (rigidity, resting tremor, bradykinesia).
- Parkinson's is closely tied to loss of dopamine from the substantia nigra.

Clinical relevance for RMTs Recognize rigidity and tremor; massage may temporarily ease tone and discomfort — adjust pacing, positioning, and client expectations within scope.



Limbic System

- Made of components in the floor of the cerebrum and in the diencephalon; the primary brain area involved in emotion and memory, and it plays a role in olfaction.
- Hippocampus — the key area for long-term memory.
- Amygdala — responsible for fear and the recognition of fear and emotions in others.
- Closely tied to the stress response and to autonomic output (via the hypothalamus).

Clinical relevance for RMTs The limbic–autonomic link underpins trauma-informed, relaxation-focused care; touch can influence emotional state — obtain consent and monitor the client's response.



SECTION 5

Brain Injuries

From mild traumatic brain injury to catastrophic hemorrhage — recognizing red flags, contraindications, and emergencies.



Overview & Classification

- Include all structural damage to the head, from mild traumatic brain injury (mTBI / concussion) to catastrophic emergencies.
- Most commonly occur during motor-vehicle accidents, falls, sports injuries, and assaults.
- Direct (primary) injuries — occur immediately from external forces applied to the head; often focal lesions, lacerations, or hemorrhage.
- Indirect (secondary) injuries — develop after the initial impact; usually more diffuse, multifocal damage.

Clinical relevance for RMTs Any suspected acute head injury is a medical emergency and an absolute contraindication to massage — stop and activate emergency care.



Direct Injury — Coup / Contrecoup

- The brain floats in cerebrospinal fluid (CSF).
- With acceleration/deceleration, the brain moves through the CSF and strikes the cranium (due to external forces).
- Coup — injury at the site of impact (primary).
- Contrecoup — injury on the opposite side as the brain rebounds against the skull (secondary).

Clinical relevance for RMTs This is the mechanism behind concussion. Post-concussion clients need physician clearance and graded, symptom-guided care before hands-on treatment progresses.



Indirect (Secondary) Injury

- After a direct injury, damage to the cerebral blood supply or a buildup of fluid can spark secondary problems.
- Ischemia — reduced blood flow and oxygen to brain tissue.
- Cerebral edema — swelling within the fixed space of the skull.
- Increased intracranial pressure (ICP) — can compress brain tissue and become life-threatening.

Clinical relevance for RMTs Worsening headache, vomiting, drowsiness, confusion, or unequal pupils after a head injury signal rising ICP — this is an emergency requiring immediate referral.



Cerebral Hematomas

Vascular damage causes bleeding in or around the brain that builds up and puts pressure on the cerebrum. Three main types, defined by where the blood accumulates:

Type	Location	Source of bleed	Onset
Epidural	Between the skull and the dura	Usually arterial — middle meningeal artery (sometimes a dural venous sinus)	Rapid — immediate medical emergency
Subdural	Between the dura and the arachnoid	Usually venous — bridging cerebral veins before they enter the sinuses	Slower (2–10 days) — still an emergency
Intracerebral / Subarachnoid	Within brain tissue / the subarachnoid space	Usually arterial — cerebral arteries; common in frontal & temporal lobes; aneurysm or severe head movement	Major medical emergency



Hematoma Signs & RMT Red Flags

- Symptoms are highly dependent on where the bleed is occurring and its size.
- General hematoma signs: pain, swelling, and redness.
- Cerebral hematoma signs: headache, weakness, difficulty speaking, confusion, and loss of consciousness (also possible: unequal pupils, vomiting, sudden 'worst headache of life').
- Keep a high index of suspicion for delayed subdural bleeds in older adults, clients on anticoagulants, or after a recent fall.

Clinical relevance for RMTs RMT action: stop treatment, do not massage, and call emergency services. A suspected intracranial bleed is a life-threatening, absolute contraindication.

Key Takeaways

- Brainstem — conduit for all tracts, vital autonomic centres, cranial-nerve nuclei, and the reticular formation/RAS for arousal.
- Motor and sensory pathways cross (decussation), so brain lesions present contralaterally.
- Cerebellum coordinates movement and balance; dysfunction produces ataxia.
- Diencephalon relays (thalamus) and regulates homeostasis (hypothalamus → ANS & endocrine) — the basis of the relaxation response.
- Cerebrum — organized into lobes, with motor/sensory gyri, white-matter tracts, basal ganglia, and the limbic system.
- Brain injuries and hematomas are red flags and absolute contraindications requiring emergency referral.



REVIEW & SCOPE

Thank you

Practising within scope

Use neuroanatomy to inform assessment, treatment adaptation, and safe positioning — not to diagnose. When neurological red flags appear (altered consciousness, new weakness or sensory loss, ataxia, or signs of an intracranial bleed), refer promptly to the appropriate health professional or emergency services.

Alignment

Content supports the CMTCA inter-jurisdictional competencies and standards of practice for safe, ethical, evidence-informed care. Adapted from the course lecture "Neuroanatomy and Pathophysiology 2."