Greater Manchester
Critical Care
Skills Institute

Critical Care Programme

Fundamentals Module
Neurological Workbook

Acknowledgements

This document has been adapted from the core workbooks associated with the Greater Manchester Multi-professional Critical Care Programme (2001-2011). As such, all contributors are acknowledged by the Greater Manchester Critical Care Skills Institute.

This version of the workbook has been compiled and completed by our team of practice educators involved in the delivery and development of our current Critical Care Programme.

Aim of the workbook

To act as a support tool for pre-course preparation and on-going learning. It is a vital resource for students on our Critical Care Programme preparing for the Fundamentals Module Neurological Study Day. It is recommended students complete the workbook prior to attending the study day. **Before you begin, locate an anatomy and physiology textbook to assist you with some of the exercises.**

On completion of the 1st section of this pre course reading and exercises it is intended you will be able to

- Demonstrate an awareness of the anatomy and physiology of the brain and nervous system which will be assessed by undertaking a formative quiz on the acute care module
- Discuss how to perform a neurological assessment, incorporating the Glasgow Coma Score
- Discuss the care and management of a variety of neuromedical conditions requiring critical care which will be assessed via formative feedback and peer assessment from group work

On completion of the 2nd section of this pre course reading and exercises it is intended you will be able to

- Identify different types of head and brain injury
- Demonstrate an understanding of the management and care of patients with head and brain injury who require critical care
- Demonstrate an understanding of ICP monitoring and management
- Demonstrate an awareness of brain stem death testing

Further Suggested sources of information are:

Practice supervisor/Mentor	Neurological and Neuro Surgical specialists
Pharmacist	Library
Intensive Care Unit Staff	Internet website access

The assessment and management tool being used throughout this book is based on the Greater Manchester Acute Illness Management 5th Edition (2014) course. This is a systematic method of assessment, which is as follows: -

A= Airway B= Breathing
C=Circulation D= Disability E= Exposure

The Brain and Nervous System

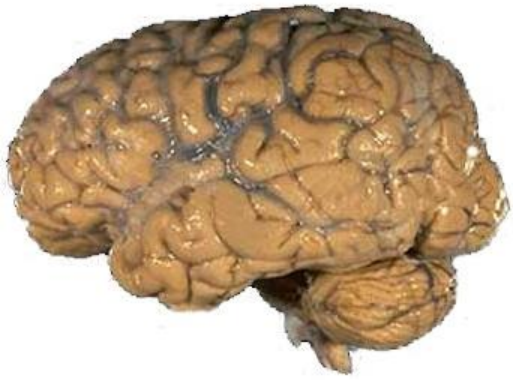
Introduction

This material will cover the anatomy and physiology of the brain and nervous system in detail. This is vital to ensure the understanding of how the brain and nervous system are affected by injury and disease and thereby recognising the care and treatment needs of persons with damage to this system.

The Nervous System

The nervous system is comprised of anatomic divisions, the Central Nervous System (CNS), consisting of the Brain and the Spinal Cord contained within the skull and vertebral column; and the Peripheral Nervous System (PNS), consisting of the cranial and spinal nerves, their peripheral combinations and the peripheral portions of the autonomic nervous system.

The Brain



The brain is the most complex structure in the known Universe. It comprises many highly specialized component parts each of which is associated with specific tasks, for example memory and vision.

The functioning of the human brain not only allows us to sense our environment and coordinate movements but also gives rise to attributes such as consciousness.

Consciousness is difficult to define and includes such attributes as a sense of past and future, an inner voice and self-awareness. Hickey, (2013) defines consciousness as “a general awareness of oneself and the surrounding environment; it is a dynamic state and can, therefore, change.” Level of consciousness is the earliest and most sensitive indicator of global brain damage.

Intelligence is commonly interpreted as the external sign of a conscious being. It is the result of millions of years of evolution. The distant origins of the human brain can be seen in simple reptiles and mammals.

The adult human brain weighs an average of 1.4 kg, or about 2% of the total body weight. It contains approximately 100 billion neurons. These neurons make up the most complex and highly organized network.

The human brain is responsible for managing the daily operations of the human body and for interpreting the vast amount of information it receives.

It is responsible for many of the qualities that make each individual unique, i.e. thoughts, feelings, emotions, talents, memories, and the ability to process information. The brain is responsible for maintaining homeostasis by controlling and integrating the various systems of the body.

Anatomy and Physiology

Central Nervous System

Bony and membranous coverings protect the brain and spinal cord. It is cushioned by cerebrospinal fluid. The skull is a rigid compartment of fused bones that covers the brain. In its base is a large opening known as the Foramen Magnum, which is where the cranial cavity and the vertebral canal meet. There are many other smaller openings in the skull that provide channels for cranial nerves and blood vessels. Three layers of membranes known as meninges also protect the brain and spinal cord. These are:

1. Dura Mater – A tough outer covering lining the skull, extending through the foramen magnum and lines the vertebral column (although does not attach to the vertebral column itself). It is separated from the arachnoid mater by the subdural space through which many fine blood vessels pass.
2. Arachnoid Mater – A delicate impermeable membrane that is separated from the third layer by the subarachnoid space.
3. Pia Mater – this is the innermost layer of membrane that adheres to the brain and the spinal cord.

The subarachnoid space contains cerebrospinal fluid (CSF). Large subarachnoid spaces at the base of the brain are known as cisternae (cisterns).

CSF circulates upwards and over the surface of the brain and downwards around the spinal cord providing a “cushioning” effect against trauma for these structures. The fold of the meninges provides support for the spinal cord and the brain. The dura folds vertically along the mid-saggital line within the skull to form the ‘falx cerbri’.

This is the fold that separates the two cerebral hemispheres. At the superior and inferior

boundaries the layers of the falx cerbri separate and form the superior and inferior longitudinal sinuses that function as cerebral veins.

At the posterior end of the falx cerebri the dura projects laterally and forms the tentorium cerebelli (this is an important landmark in brain used to describe sites of lesions e.g. supratentorial, etc). The tentorium cerebelli supports the temporal and occipital lobes and separates posterior cranial fossa from the rest of the cranial cavity. The pia mater is closely attached to the surface of all of the folds/ "bumps" of the brain, (the gyri). The furrows/fissures of the brain are known as sulci.

The central nervous system can be divided into six major regions:

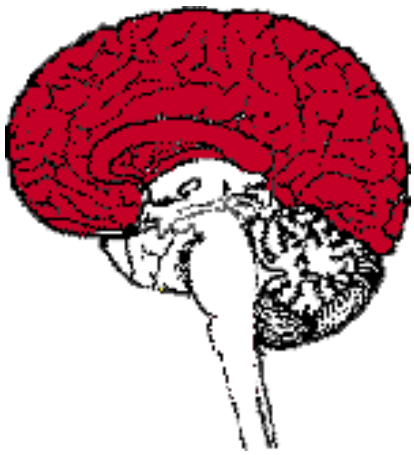
1. Telencephalon (cerebrum)
2. Diencephalon (thalamus and hypothalamus)
3. Mesencephalon (midbrain)
4. Metencephalon (divided into the pons and cerebellum)
5. Myelencephalon (medulla)
6. Spinal Medulla (spinal cord)

You will often hear the areas of the brain referred to as, Forebrain = Telencepahlon and Diencephalon, Mid Brain = Mesencephalon and Hind Brain= Myelencephalon and Metencephalon

1. Cerebrum (Telencephalon)

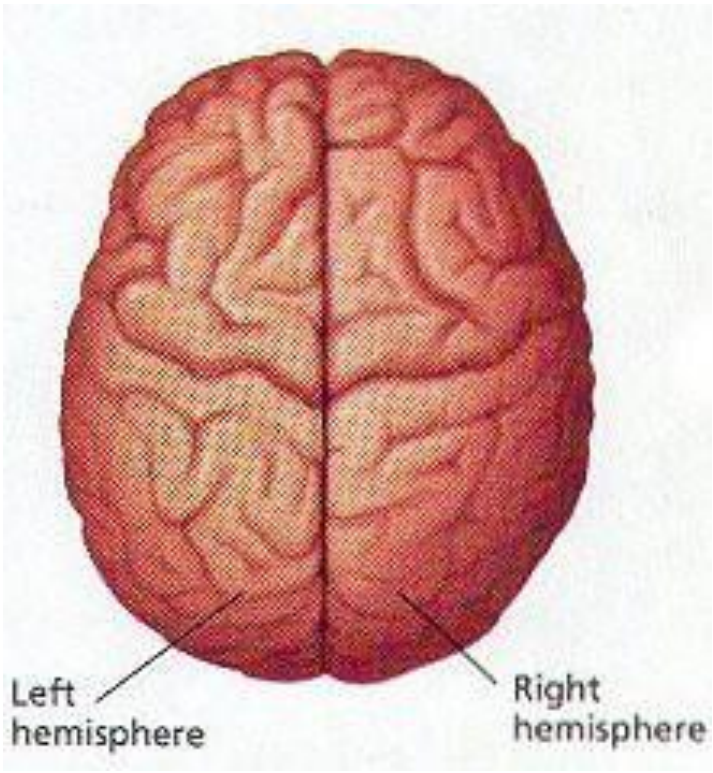
The cerebrum is the control centre of the brain and is the largest and most prominent part of the brain being 85% of the weight and occupying most of the space in the skull. It is responsible for all of the voluntary (conscious) activities of the body. It is also the site of intelligence, learning and judgement, language, conscious thought, vision and other senses and personality development. The Cranial Nerve -Olfactory Nerve (I) originates here.

The cerebrum is divided into two cerebral hemispheres (Left and Right) by a deep groove however they are joined at the base by the corpus callosum together with a bundle of neurons known as a tract. This tract tells each half of the brain what the other half is doing. The cerebrum has prominent folds and grooves that increase the surface area. It is important to note that the *left* hemisphere of the cerebrum controls the *right* side of the body and the *right* side controls the *left* side. The left side to the right side and vice versa sends sensations and commands to muscles. The *right* hemisphere is associated with creativity and artistic ability whereas the *left h*emisphere is associated with analytical and mathematical ability.



The cerebrum contains thick layers of unmyelinated neurons that have a grey appearance hence the term grey matter. Each hemisphere of the cerebrum is divided into four regions known as lobes. These lobes are named after the skull bones that cover them. The cerebrum has two surfaces – A folded outer surface called the cerebral cortex (unmyelinated neurons/axons - grey matter) and the inner surface called the cerebral medulla made up of myelinated neurons/axons – white matter.

In summary, the cerebrum determines intelligence, and personality, motor function, planning and organisation, interpretation of sensory impulses, sense of smell and touch sensation.



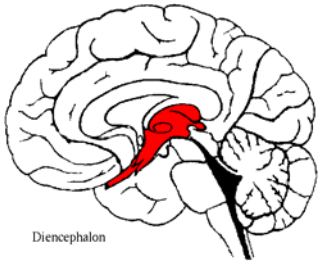
Take some time now and revise the anatomy and physiology of the brain in more detail and then complete the questions below:

Name the four lobes of the brain and their main functions.

1.	**Name:** **Function /s:**
2.	**Name:** **Function /s:**
3.	**Name:** **Function /s:**
4.	**Name:** **Function /s:**

2. Diencephalon

This is the area of the brain that includes the thalamus, hypothalamus, epithalamus and subthalamus. It is located above the mesencephalon of the brain stem and surrounds the third ventricle. Optic Nerve (II) and the Optic Chiasm are in this area.



2.1 The **thalamus** is a large, two-lobed grey matter structure located at the top of the brain stem. It contains several relay nuclei, most of which lead directly to the cortex. It is adjacent to the third and on the floor of the fourth ventricle. It has both sensory and motor functions. Almost all sensory information enters this structure where neurons send information to the overlying cortex.

Axons from every sensory system (except olfaction) synapse here, as the last relay site before the information reaches the cerebral cortex. It may play a role in learning and memory. It influences mood, fear, rage, love and hate. It also contains many nuclei that are concerned with specific senses such as touch and temperature.

2.2 The **Hypothalamus** is comprised of 22 nuclei. The pituitary gland has an influence on the endocrine and the autonomic nervous system; this helps regulate homeostasis and hormones. It is attributed as co-ordinating behaviours such as sleeping, sex, feeding, temperature control/regulation, emotions, and fluid balance and muscle control.

2.3 Within the **Epithalamus** the pineal gland may influence sleep-wake cycle. Its other function is the connection between the limbic system to other parts of the brain, and the regulation of hunger and thirst by the habenula.

2.4 The **Subthalamus** is involved in controlling motor functions.

In summary the diencephalons is responsible for chewing, equilibrium, eye movement, vision, facial sensation, hearing phonation, respiration, salivation, swallowing, smell, taste and directing sense impulses throughout the body.

3 Mesencephalon (midbrain)

This is positioned between the hindbrain and the forebrain, where it forms part of the brainstem connecting it to the forebrain. The midbrain is responsible for controlling sensory processes. It is also the rostral part of the brainstem that, if impaired in its core (i.e. the **tegmentum**), will result in the loss of consciousness or coma, because the rostral manages the end of the reticular formation. The oculomotor Nerve (III) and the Trochlear Nerve (IV) originate here.

The dorsal or posterior part has the **superior colliculus**, which is important for visual system reflexes, and the **inferior colliculus**, which is important for auditory system function.

The ventral or anterior part has the **cerebral peduncle**, which is a huge bundle of axons travelling from the cerebral cortex into/ through the brainstem; those fibres are important for voluntary motor function. Two other structures in the depth of the midbrain that are important for normal motor function are the **red nucleus** (not visible) and the **substantia nigra**. The trochlear nerve comes out of the posterior surface of the midbrain, below the inferior colliculus. In summary then this area controls responses to sight, eye movement, pupil dilation, body movement, and hearing.

4 Metencephalon (divided into the pons and cerebellum)

The metencephalon is a developmental categorization of portions of the central nervous system. The metencephalon is composed of the pons and the cerebellum; contains a portion of the fourth ventricle; and the trigeminal nerve V, abducens nerve VI, facial nerve VII, and a portion of the vestibulocochlear nerve VIII.

4.1 Pons

The **pons** (sometimes **pons Varolii** after Costanzo Varolio) is a protuberance on the brain stem. It is part of the autonomic nervous system and the Pontine Nuclei, located in the anterior portion of the pons, relay information from the cerebrum to the cerebellum. It is just superior to the medulla oblongata is the pons, which contains ascending and descending nerve tracts and several nuclei. Other important pontine areas include the Pontine Sleep and the respiratory centre.

The Nuclei for Cranial Nerves trigeminal V, abducens VI, facial VII, vestbulocochlear VIII are contained within the posterior pons.

4.2 Cerebellum

The cerebellum is the second largest part of the brain. It is a small cauliflower shaped structure located at the back of the skull. It coordinates and balances muscle movements so that the body can move gracefully and efficiently.

The cerebellum controls balance, posture and coordination. It receives sensory impulses from muscles, tendons, joints, eyes and ears together with input from other parts of the brain. Processing information about position it controls posture by keeping skeletal muscles in a constant state of partial contraction. The cerebellum coordinates rapid and ongoing movements.

The cerebellum appears to be related to the learning of how to perform physical activities through training the cerebellum to coordinate the correct muscles. The cerebellum function is involuntary therefore learning a completely new physical activity can be very difficult.

5 Myelencephalon (medulla)

This is approximately the inferior 3cm of the brain stem and it is continuous through the foramen magnum of the skull with the spinal cord.

In the anterior portion of the pons are the corticospinal fibres that mostly cross over in the medulla and continue down the cord as the corticospinal tracts these are involved in voluntary movement.

Several obvious nuclei are present in the posterior part of the medulla. These are the areas for synapses of any ascending pathways carrying sensory information. The nuclei of the cranial nerves are the IX glossopharyngeal, X vagus, XI accessory and XII hypoglossal.

Some parts of the cranial nerve nuclei form the "Vital Centres" of the Medulla. These centres include the following:

Cardiac Centre Cardio-acceleratory and cardio-inhibitory centres are basically reflex centres, receiving impulses that arise in receptors in several body areas and sending impulses to the heart to regulate its rate of beat according to the need for oxygen and activity levels.

Respiratory Centre Inspiratory, expiratory, apneustic and vagal nuclei form part of the system responsible for intake of air into the lungs and further expiratory activity.

VasoMotor Centre Vasodilator and Vasoconstrictor centres are concerned with the diameter of muscular blood vessels and thereby help to control the blood pressure.

Another important part of the medulla is a group of cells known as **THE RETICULAR ACTIVATING SYSTEM or RETICULAR FORMATION (RAS).** The Reticular Activation System (RAS) actually helps to alert, or awaken, the upper parts of the brain, including the cerebral cortex.

6 Spinal Medulla (spinal cord)

The spinal cord acts as a communication link between the brain and the peripheral nervous system (PNS). It is continuous with the brain and emerges from an opening at the base of the skull. The spinal cord stretches downward for approximately 42 - 45 cm through the vertebral column.

There are 31 pairs of spinal nerves, (these are part of the PNS), that emerge from the spinal cord and branch out to both sides of the body. The nerves are named according to their respective vertebrae. Nerves are axons that are bundled together. Each spinal nerve consists of a **Dorsal Root** and a **Ventral Root.** These dorsal roots contain neurons that carry signals to the CNS from various types of receptors. The **Ventral Roots** contain the axons of motor neurons that contact and carry information to the muscles and glands effectors. Within the spinal cord and elsewhere in the body there are Interneurons – these are neurons that connect neurons to each other. In addition to carrying impulses to and from the brain, the spinal cord regulates reflexes. A reflex is the simplest response to a stimulus. Sneezing and blinking are two examples of reflexes. A reflex

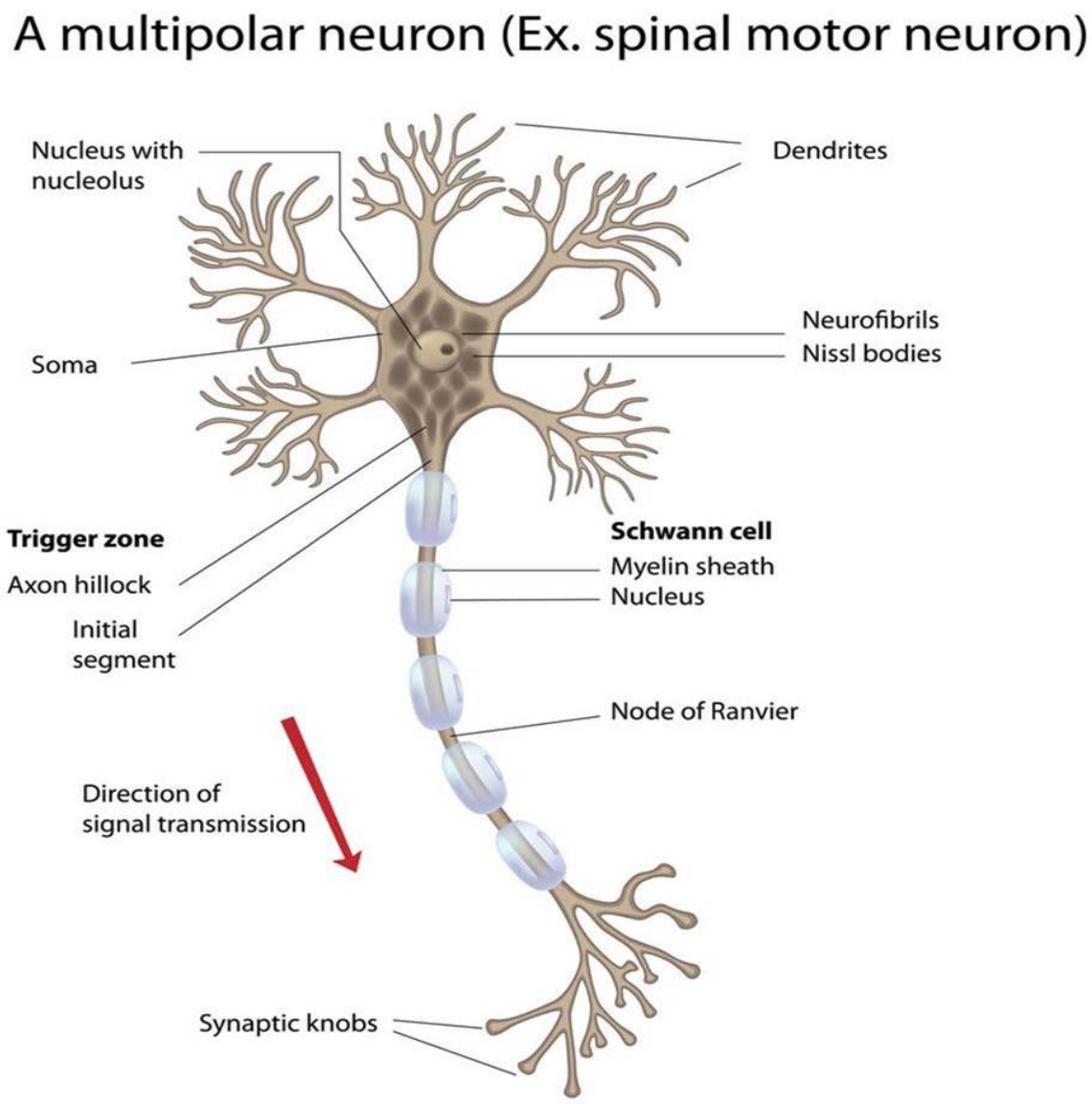
produces a rapid motor response. Reflexes are very fast, and most reflexes never reach the brain.

The CNS is divided into two main components, these are

1. The Brain

2. The Spinal Cord

Familiarise yourself with a neuron in relation to Myasthenia Gravis and Guillian Barre syndromes make some notes about how the two disease processes affect the neuron in different ways.



Notes…….

Below are the 3 areas of the brainstem and their function/s

	NAME	FUNCTION/S
1.	Medulla	- Pathway for motor & sensory impulses
	Oblongata	- Consciousness & arousal - 3 reflex centres
		- Cranial nerves viii, ix, x, xi, xii originate here
2.	Pons	- Relays impulses from one side to the other - Cranial nerves v, vi, vii, viii.
3.	MidBrain	- Relays motor impulses from cerebral cortex to the pons & sensory impulses from the spinal to the Thalamus - Cranial nerves iii, iv originate here

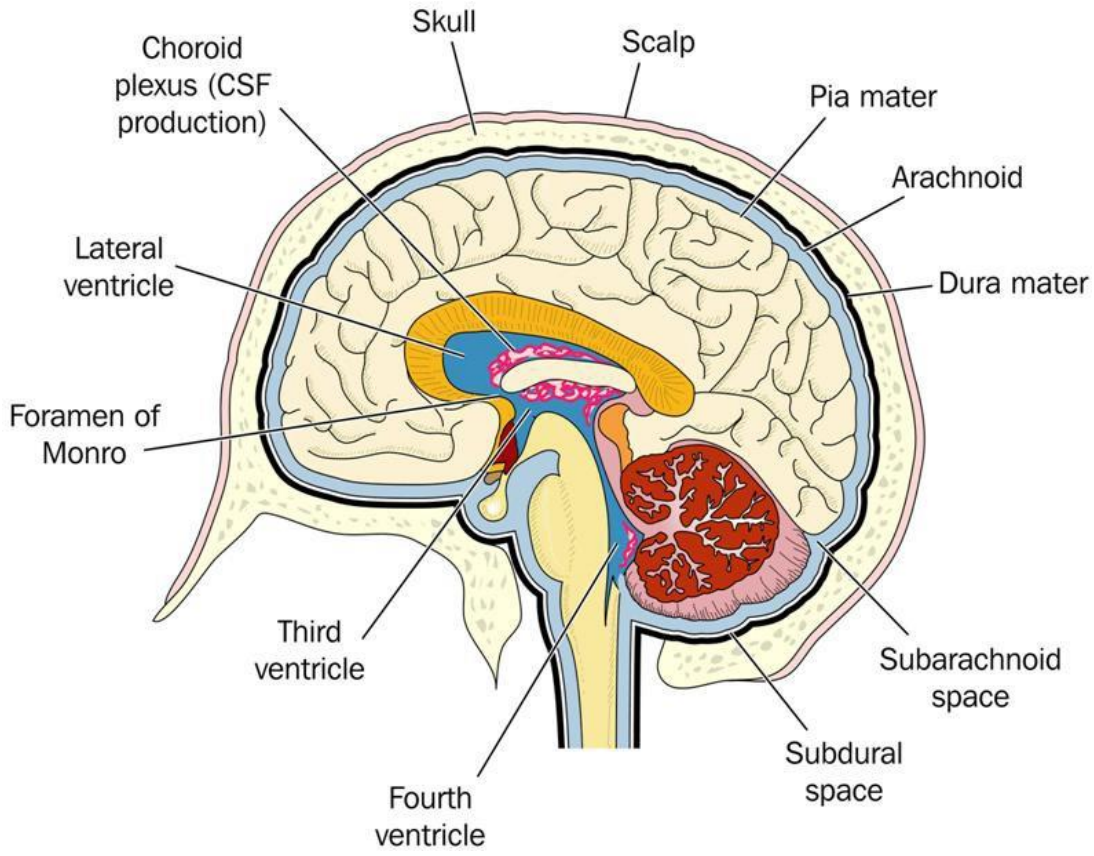
Cerebro Spinal Fluid

What are the functions of cerebrospinal fluid?

Functions

Formation

This Diagram illustrates the formation of Cerebral spinal fluid



Identify how many layers of meninges there are and describe their structures

How many layers are there?

What is their function?

Cerebellum

Is responsible for coordination of voluntary motor movement

- Balance
- Equilibrium
- Muscle tone

Reticular Formation

Reticular Formation is a core of neural tissue in the brain stem

Alerts the cerebral cortex to incoming sensory signals:

- Arousal
- Attention
- Cardiac Reflexes
- Motor Functions
- Regulates Awareness
- Relays Nerve Signals to the Cerebral Cortex
- Sleep

Spinal Cord

The spinal cord has two major functions:

- Transmit impulses to and from the brain
- House spinal reflexes.

Tracts that carry sensory information to the brain are called ascending tracts; whilst tracts that carry motor information from the brain the brain are called descending tracts

The names that identify nerve tracts identify the origin and termination of the fibres within the tract.

How many pairs of spinal nerves do we have?_____ pairs

Name the 12 cranial nerves and their functions

	NAME	FUNCTION
I	Olfactory	Sense of smell
II		
III		
IV		
V		
VI		
VII		
VIII		
IX		
X		
XI		
XII		

To help remember the order of the cranial nerves try to learn the mnemonic: **O**n **O**ld **O**lympus **T**owering **T**op **A** **F**amous **V**ocal **G**erman **V**iewed **S**ome **H**ops.

To help remember the type of cranial nerve (motor or sensory) try to learn this mnemonic:
Some Say Marry Money, But My Brother Says Big Breasts Matter More
Sensory, sensory motor, motor, both, motor, both, sensory, both, both, motor, motor in the order of cranial nerves starting from the olfactory (cranial nerve I).

Peripheral Nervous System (PNS).

Like the CNS, the PNS is split into two components

1. Sensory-somatic system that consists of the cranial nerves and spinal nerves

2. Autonomic system that is further split into the parasympathetic and sympathetic system

Let's look at these in more detail.

Sensory-somatic System

The **somatosensory system** includes several types of sensation from the body, such as light touch, pain, pressure, temperature, and joint and muscle position sense (also called proprioception).

There are three different pathways in the spinal cord that help in these processes and each have different targets in the brain. Any sensory system going to the cerebral cortex will have to cross over at some point, because the cerebral cortex operates on a contralateral opposite side-to-side basis.

The first is called **discriminative touch**, which includes touch, pressure, and vibration perception, an example is the brains ability to analyse the raised letters with our fingertips, or describe the shape and texture of an object without seeing it. The discriminative touch system crosses high in the medulla.

The second is **pain and temperature**, which is just what it sounds like, and also includes the sensations of itch and tickle. The pain system crosses low - in the spinal cord.

The third is **proprioception**, and includes receptors for what happens below the body surface: muscle stretch, joint position, tendon tension, etc. This primarily targets the **cerebellum**, which needs continuous feedback on what the muscles are doing. The proprioceptive system is going to the cerebellum, which works ipsilaterally, the same side. Therefore this system doesn't cross.

Autonomic Nervous System

The autonomic nervous system ANS consists of sensory and motor neurons that run between the central nervous system (especially the hypothalamus and medulla oblongata) and various internal organs such as the heart, lungs and liver. The ANS is a regulatory structure that helps the body adapt to changes in their internal/external environment. It adjusts or modifies some functions in response to stress, i.e. "Fight or Flight". The ANS helps to regulate: -

- blood vessels' size and diameter affecting blood pressure
- the heart's rate, electrical activity and ability to contract
- the diameter of the bronchus

The ANS also regulates the movement and work of the stomach, intestine and salivary glands, the secretion of insulin and the urinary and sexual functions. The ANS acts through a balance of its two components, the sympathetic nervous system and parasympathetic nervous system.

Listed are the effects the parasympathetic and sympathetic systems have on the following: -

	Parasympathetic	**Sympathetic**
Lungs	Decreases diameter of airways / bronchi Decreases respiratory rate	Increases diameter of Airways / bronchi Increases respiratory rate
Heart	No effect on blood vessels (not innervated) **Heart:** Decreases heart rate, force of contraction, and blood pressure	Vasoconstriction and vasodilation of blood vessels **Heart:** Increases heart rate, force of contraction, and blood pressure
Pupils	Constriction of pupil; focusing for near vision	Dilation of pupil; focusing for distance vision
Gut	**General level of activity:** Increases activity (Nausea, vomiting, abdominal cramps, diarrhoea, increased peristalsis and tone, sphincters relaxed)	**General level of activity:** Decreases activity (Constipation, intestines relax, decreased peristalsis and tone)
Liver	Glycogen synthesis	Glycogen breakdown and glucose synthesis and release

Cerebral Circulation

Although the brain is approximately 2% of the body's total weight, it utilises 20% of the cardiac output. Blood is supplied via the two internal carotid arteries and the two vertebral arteries. These join at the base of the brain forming the Circle of Willis. It also utilises 20% of all oxygen content in the body. The carotid arteries and their branches supply the anterior portion of the brain whereas the vertebrobasilar system supplies the posterior portion of the brain.

The brain receives its blood supply from the heart by way of the aortic arch that gives rise to the

brachiocephalic otherwise known as the innominate artery, left common carotid artery and the left subclavian artery.

Venous blood flows peripherally via superficial cerebral veins and centrally via the deep cerebral veins into the venous sinuses. These lie between the outer endosteal and the inner meningeal layer of the dura, which in turn drain into the internal jugular veins. The cerebral veins are thin walled and have no valves. There are numerous venous connections between cerebral veins, dural sinuses, venous systems of the meninges, skull, scalp and nasal sinuses. This can facilitate the propagation of thrombus or spread of infection between these vessels (Sheldon 1981).

Cerebral blood flow (CBF) is about 50-ml/100 g of brain/minute (approx 750 mls/min). Studies have shown that CBF and cerebral metabolism is higher in the grey matter than the white matter. This means that the oxygen extraction fraction (OEF) remains about the same (approximately 40%) throughout the brain, therefore, in normal resting human brain CBF is a reliable reflection of cerebral metabolism (Leenders et al 1990).

CBF depends on cerebral perfusion pressure (CPP) and cerebrovascular resistance. The perfusion pressure is the difference between systemic arterial pressure and venous pressure at the exit of the subarachnoid space, the latter being estimated by the intracranial pressure.

Cerebral Blood Flow

Cerebral blood flow is calculated by subtracting the ICP from the mean arterial pressure (MAP) and dividing by the cerebrovascular resistance (CVR), or by dividing cerebral perfusion pressure (CPP) by CVR.

$$CBF = \frac{MAP - ICP}{CVR} \quad \textbf{or} \quad \frac{CPP}{CVR}$$

Average CBF	50 ml/100 Gm/min
Ischemia CBF	< 18 – 20 ml/100 Gm/min
Tissue death	< 8 – 10 ml/100 Gm/min
Hyperemia (CBF in excess of tissue demand)	> 55 – 60 ml/100 Gm/min

Below describes the Blood Brain Barrier, and explains how it works and why it is important

How it works:

The BBB is semi-permeable; that is, it allows some materials to cross, but prevents others from crossing. In most parts of the body, capillaries, are lined with endothelial cells. Endothelial tissue has small spaces between each individual cell so substances can move readily inside and the outside of the vessel. However, in the brain, the endothelial cells fit tightly together and substances cannot pass out of the bloodstream. (Some molecules, such as glucose, are transported out of the blood by special methods.) Glial cells (astrocytes) form a layer around brain blood vessels and may be important in the development of the BBB. Astrocytes may also be responsible for transporting ions from the brain to the blood.

Functions of the BBB –

1. Protects the brain from "foreign substances" in the blood that may injure the brain.
2. Protects the brain from hormones and neurotransmitters in the rest of the body.
3. Maintains a constant environment for the brain.

General Properties of the BBB

1. Large molecules do not pass through the BBB easily.
2. Low lipid (fat) soluble molecules do not penetrate into the brain. However, lipid soluble molecules, such as barbituate drugs, rapidly cross through into the brain.
3. Molecules that have a high electrical charge to them are slowed.

The BBB can be broken down by:

1. Hypertension (high blood pressure): high blood pressure opens the BBB
2. Development: the BBB is not fully formed at birth.
3. Hyperosmolitity: a high concentration of a substance in the blood can open the BBB.
4. Microwaves: exposure to microwaves can open the BBB.
5. Radiation: exposure to radiation can open the BBB.
6. Infection: exposure to infectious agents can open the BBB.
7. Trauma, Ischemia, Inflammation, Pressure: injury to the brain can open the BBB

Neurological Assessment

Neurological assessment is usually instigated for patients who have an acute or potential neurological injury. When used in conjunction with other assessments such as haemodynamic parameters, early warning markers must be acted on promptly, to prevent irreversible neurological damage or even death.

A neurological Assessment needs to: -

- Establish a baseline
- Determine changes from the baseline, as changes in neurological status can be slow as in the case of extension of a cerebral infarction or rapid as in the case of herniation.

Knowledge of anatomy and physiology is vital to carry out a neurological assessment and enables comparison and contrast of a patient's neurological condition.

There are various elements to a substantive and thorough assessment that can be used to determine a patient's condition.

The NICE guidelines – Clinical Guideline 4 – Head Injury (June 2003) for the management of head injuries state that the minimum documented observations for the patient presenting with a head injury are as follows: -

- Glasgow Coma Scale (GCS)
- Pupil size and reactivity
- Limb movement
- Respiratory rate
- Heart rate
- Blood pressure
- Temperature
- Oxygen saturations

In addition it is important to record the Blood Glucose Level as part of a full neurological assessment.

Why is blood sugar monitoring important in patients with neurological conditions?

AVPU

A quick neurological assessment can be done using the AVPU scale, which is incorporated into many Early Warning Scoring systems. To record the AVPU, work your way down the list, and choose the highest category that the patient fits into.

A – **A**lert	- Conscious and able to answer correctly: name, date, time location, what happened
V - responds to **V**oice	- Not alert, is semiconscious but responds to shouts or questions even if just groans or moans
P - responds to **P**ain	- Moves or groans in response to pain
U – **U**nresponsive	- No response at all is elicited

Start by checking to see if the patient is awake. If not, then talk to them. If that doesn't work then try inflicting a mildly painful stimulus such as a trapezium pinch or supra orbital pressure. If no response is elicited then the patient is recorded as being **U**nresponsive. It is not acceptable to use sternal rubs, or sqeezing a patients nail bed. This does not provide central stimulation which is what the observation is intended to simulate.

Any patient scoring less than **Alert** should have a more in depth assessment carried out. Patients who score **P** or **U** have a Glasgow Coma Score of 8 or less and immediate medical intervention should be sought.

The scale is not suitable for long term neurological observation of the patient - the Glasgow Coma Scale must therefore be used.

Glasgow Coma Scale

Teasdale and Jennett, to assess a patient's level of consciousness and arousal, created this scale in 1974. It is made up of 3 components: -

- Eye opening
- Motor response
- Verbal response

Although the scale has limitations, particularly with respect to an intubated patient, as you cannot assess verbal response in a patient with an endotracheal tube it is still the best tool available some 30 years after its creation.

GLASGOW COMA SCALE		
Type	**Assessment**	**Score**
Eye Opening (E)	Spontaneously	4
	To Speech	3
	To Pain	2
Best Verbal Response (V)	None	1
	Orientated	5
	Confused	4
	Inappropriate words	3
	Incomprehensible sounds	2
Best Motor Response (M)	No Response	1
	Obeys	6
	Localises	5
	Withdraws to pain	4
	Abnormal Flexion (Decorticate)	3
	Extensor Response (Decerebrate)	2
	No Response	1
TOTAL SCORE	**E + V + M = total score**	**3 - 15**

- Please note there may be a slight difference in the wording of the above depending on the area providing care.
- A score of 15 denotes a fully conscious patient, less than 8 denotes a coma, and the lowest score obtainable is 3
- For a more accurate handover the score should be handed over in the 3 sections, e.g. E, M, and V
- If a patient scores 12/15 it tells you more if that is communicated as Eyes = 4, Motor = 5, Verbal = 3 or as you may see it documented as E4, M5, V3. NICE Clinical Guideline 4 Head Injury (June, 2003)

Painful Stimuli

For the purpose of the GCS painful stimuli should always be inflicted centrally. This is because you are trying to assess higher brain function. Peripheral painful stimuli, e.g. pushing on the side of a patient's finger can elicit a spinal reflex giving a false impression.

Examples of central painful stimuli are: -

- trapezius pinch
- supraorbital push

Why would you not use the sternal rub if you were doing regular Neurological observations?

Pupil response

Pupils should be checked for size and shape before you shine the light in the eye. Shining a light in each eye and observing for constriction of the pupil should then check the reaction. Both eyelids must be held open simultaneously whilst checking pupils. It is important to observe both pupils while shining a light in the other. Both pupils should constrict -this is known as the consensual response.

The consensual response

This is due to the fact that stimulation of the afferent (i.e. sensory, carried with CN 2) nerves in one eye will trigger efferent (i.e. motor, carried with CN 3) activation and subsequent constriction of the pupils of both eyes.

Which cranial nerve controls pupil response?

What can make pupils appear pinpoint?

What can make pupils appear dilated?

Limb movements

This is an important addition to the GCS when assessing a patient neurologically. It is possible for a patient to have a GCS of 15 but be unable to move their limbs.

For example a patient may have suffered a stroke affecting limb function but this would not be immediately obvious using the GCS. Limb strength is assessed by using resistance is the patient obeying commands. In the patient with a reduced level of consciousness you may need to use peripheral painful stimuli to elicit a response. It is not acceptable to squeeze nail bed, the use of a tendon hammer is advocated.

Remember peripheral painful stimuli should only be used to assess limb strength and may only represent a message going as far as the spinal cord and back (spinal reflex)

List below possible reasons for a patient scoring less than 15 on the GCS.

Pre course

Post course

How did you do?

Blood Glucose Monitoring

This is an important aspect as high and low blood glucose levels can cause detriment to patients with neurological injuries. Acute hyperglycaemia is common during critical illness. There is now compelling evidence that this hyperglycaemia is harmful to patients and may increase their risk of complications and death.

In a study (Van den Berghe et al, 2001) approximately 1500 critically ill patients were randomised to receive insulin to maintain blood sugar between 4.4 and 6.1 mmol/l or their blood sugar was kept below 12 mmol/l. Patients in the strict blood glucose control group had mortality reduced by a third. If they were in the ICU for more than 5 days, mortality was halved. These dramatic improvements were also associated with a 45% reduction in the number of blood stream infections. The reasons for this are unclear but are in part due to the damaging affect that hyperglycaemia has on neutrophil function. In a study reviewing the effect of tight glycaemic control after cardiac surgery the incidence of sternal wound infection was reduced from 2% to 0.8% of patients. The mortality in the insulin group was also halved from 6% to 3%.

This increased risk of infection may also explain the reduction in survival found in burns patients who are hyperglycaemic. In a study (Gore et al, 2001) the incidence of blood stream infections in patients with hyperglycaemia was increased and their mortality was also increased to 27% in comparison with 4% in the normoglycaemia group.

Cerebral Ischaemia

Poor control of blood sugar is associated with worse neurological injury after both stroke and head injuries (Williams et al, 2002; Cherian et al, 1997; Cherian et al, 1998). It also doubles the incidence of vasospasm (Charpentier et al, 1999). As yet, the only evidence that controlling blood sugar improves outcome in neurological injury can be found in animal studies.

These calculations can be simplified as below

New rate of insulin (mls/hr)= *(***New blood sugar)** X old insulin rate

(**Old blood sugar**)

Intracranial pressure (ICP)

The Monroe-Kellie hypothesis states that, 'the skull, a rigid compartment, is filled to capacity with essentially non- compressible contents: brain matter (80%), intravascular blood (10%) and cerebrospinal fluid (10%). The volumes of these three components remain constant in a state of dynamic equilibrium. If any one component increases in volume, another component must decrease for the overall volume to remain constant, otherwise ICP will rise".

(Hickey, 2013)

In the normal state the balance of brain tissue, blood and CSF within the skull produces an ICP of less than 10mmHg. If there is an increase in one component, other components can be decreased in two ways.

1. CSF can be displaced down into the spinal system and its absorption increased.
2. Cerebral blood volume can also be reduced.

However once the limit of these compensatory mechanisms is reached the ICP rises. As compliance is lost even a small rise in the volume of the intracranial contents will cause a steep rise in the ICP. There is no defined set point at which treatment for intracranial hypertension should be initiated, but levels above 20mmHg are usually treated.

However it is probably more important to maintain an adequate cerebral perfusion pressure. In a hypotensive patient, even a small increase in ICP could be harmful. Alternatively, an elevated mean arterial pressure may protect against a raised ICP.

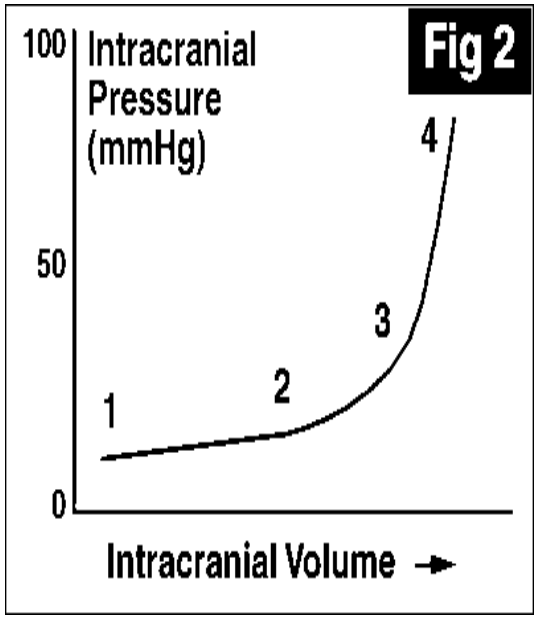
Pressure-volume curve

1. Normal ICP 0–10 mmHg

2. Increase in volume shows little change in pressure due to compensation

3. Maximum compensation

4. Small volume increase results in large pressure increase. Compliance is lost



You will be given group work on the Fundamentals Module study day

Neuromedical conditions (may require critical care)

- Status Epilepticus
- Guillain Barré Syndrome
- Myasthenia Gravis
- Meningitis

Epilepsy

Find a definition of epilepsy and write it in the box below

What types of epileptic seizures have you heard of?

You will be given group work on the acute care module study day

Status Epilepticus

This is an uncommon, but potentially life threatening condition. It is defined as an epileptic seizure that lasts for more than 20 minutes without a period of recovery in between.

The patient does not have to have had a prior diagnosis of epilepsy to suffer from status epilepticus. Some of the triggers are: -

- Frontal lobe injuries
- Post head injury
- Weaning drugs e.g. phenobarbitone
- Alcohol or sedation withdrawal
- Drug intoxication e.g. tricyclic antidepressants
- Infection
- Metabolic disturbances e.g. hyponatraemia

What are the priorities of care for a patient in status epilepticus? Refer to Appendix C of the NICE 2004 guidelines for the Epilepsies which lists the treatment of status epilepticus (Clinical guideline 20)

Your answers should include;

Airway

Breathing

Circulation

Drugs

Guillain Barré Syndrome (GBS)

GBS is an acutely evolving, immune mediated, inflammatory disorder of the peripheral nervous system, leading to demyelination and axonal loss (Hund et al 1993).

It is a condition characterised by ascending muscle paralysis often starting in the feet with an ascending pattern, although descending GBS also occurs. If the respiratory muscles are affected and vital capacity drops the patient will need to be admitted to ICU for ventilatory support.

GBS is thought to be an inappropriate immune response. It often follows a viral infection e.g. mumps, but is also associated with salmonella and campylobacter infections. It can also occur following vaccinations. It occurs most frequently between the ages of 30 and 50 years in both sexes.

Read the following article and discuss the priorities of care in the box below. Ask your mentor how using pulmonary artery catheters have changed in ICU and why.

Poulter, A. (1998) The patient with Guillain Barré syndrome: implications for critical care nursing. Nursing in Critical Care vol3 no.4 pp182-189

Respiratory

Airway management

Cardiovascular management

Pain management

Risks of immobility

Nutrition

Communication and Psychological Care

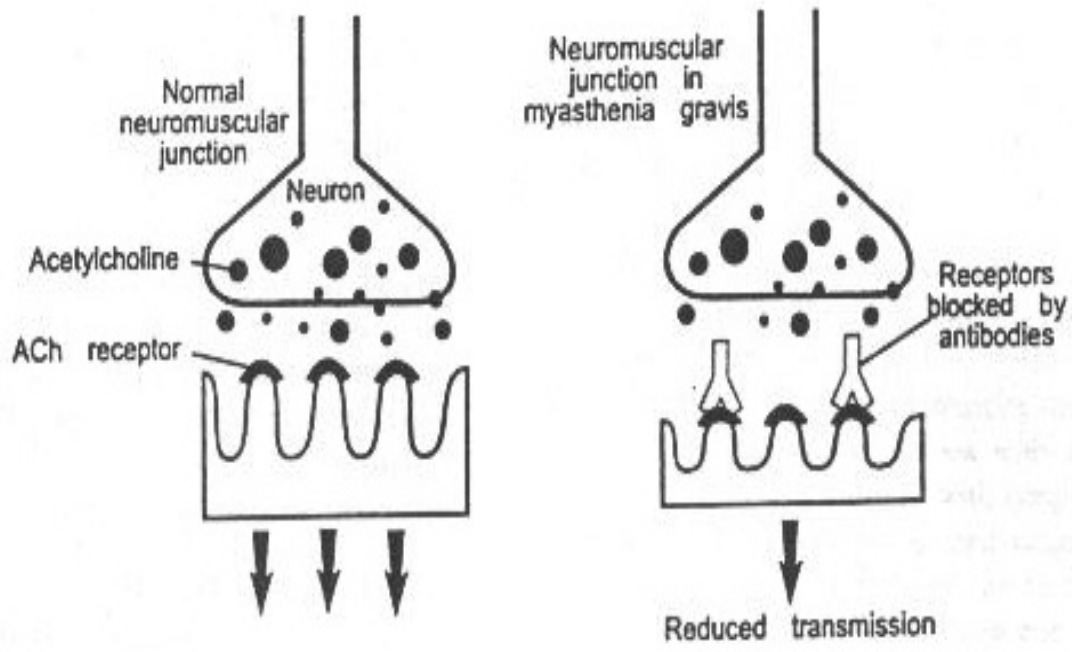
Tissue viability

Nutrition

You will be given group work on the acute care module study day

Myasthenia Gravis (MG)

This is a disorder of neuromuscular transmission characterised by weakness and fatigue of some, or all, muscle groups. It is worse following exertion or towards the end of the day.



Each muscle fibre has its own nerve, and the point of contact (the neuro-muscular junction) is where the problem lies in different forms of MG.

At the neuro-muscular junction there are nerve terminals that release a chemical called acetycholine (ACH). This diffuses across the cleft and reacts briefly with the ACH receptors in the muscle fibre membranes. This opens channels that allow electrolytes (mainly sodium) to enter the muscle fibre and this results in its contraction.

Cholinesterase is an enzyme that rapidly removes any free ACH that is present around the junction and allows muscle relaxation.

In MG there is a reduced amount of ACH available and the some of the receptors are blocked- reducing the capacity for muscle contraction. It is treated with anti- cholinesterase drugs, which help optimise the amount of ACH available for neuro- muscular transmission.

Test your knowledge!

List the presenting symptoms of MG

These tests are used to confirm diagnosis. Please identify the specifics for the tests below.

Tensilon Test

Serology

Radiology

Please name the drugs used to treat MG and how do they work?

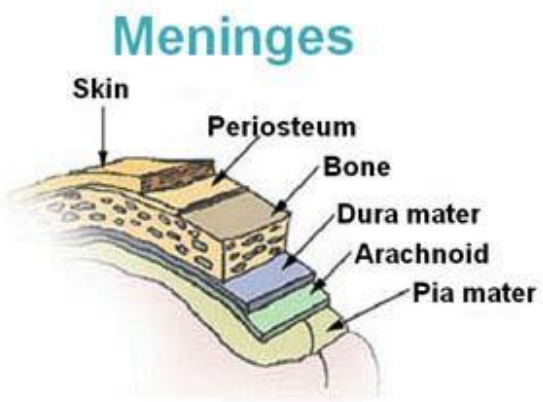
Meningitis

Meningitis can be defined as an inflammation of the protective coverings of the brain (meninges). These coverings of the brain and spinal cord are called Pia mater, Arachnoid mater and Dura mater.

- Pia mater - is closely attached to the skull and spine.
- Arachnoid mater - named due to the soft and spongy web like appearance.
- Dura mater - the thickest and toughest of the layers.

Figure 1.

Showing meninges as part of the brains protective barriers



Dura mater -- outer layer lining skull
Arachnoid (mater) -- contains blood vessels
Subarachnoid space -- filled with CSF
Pia mater -- covers brain

Source www.meningitis.org

Meningitis & Septicaemia

Meningitis and septicaemia can occur together or separately.

Meningitis is the inflammation of the meninges. Septicaemia is the blood poisoning, which occurs as a result of the bacteria entering the blood stream.

Meningitis with septicaemia is referred to as meningococcal disease.

Diagnosing meningitis is often difficult for health professionals, as symptoms may be initially vague and appear to mimic common mild or flu like illnesses.

However if there is any suspicion of meningitis treatment must be started immediately. Benzylpenicillin must be given without delay preferably intravenously or intramuscularly, if unable to gain IV access quickly.

What to look for?

Meningitis
Fever
Vomiting
Rash
Neck stiffness Photophobia
Drowsiness/difficult to wake Confused
Decreased conscious level

Septicaemia
Fever Vomiting
Limb /joint/muscle pain
Cold hands and feet/shivering Pale or mottled skin
Tachypneoa/breathlessness Rash
Drowsiness/difficult to wake
Confused
Decreased conscious level

Meningitis can be caused by viruses, bacteria or fungus, and is a serious condition. Viral and bacterial meningitis are the most common forms, although fungal meningitis exists it is extremely rare, slow in onset and difficult to treat.

However, bacterial meningitis is usually rapid in onset and can be treated with early recognition, diagnosis and appropriate treatment.

Viral meningitis is more common than bacterial, but is usually less serious. The symptoms may be similar to those of the bacterial form and an individual who has a severe case of viral meningitis will need hospitalisation and investigation to determine which type of meningitis they are suffering from, and treatment of their symptoms which can be quite debilitating.

The viruses usually responsible for viral meningitis are enteroviruses, and are present in the human bowel and are therefore found in faeces and sewage.

Bacterial meningitis is serious and it is said that at least 50 types of bacteria can result in meningitis. Although this is the case, the most common bacteria responsible for infecting adults and children is meningococcal bacteria, followed by pneumococcal which is the second biggest cause of bacterial meningitis in the UK and Ireland.

It is important that patients and healthcare workers are aware of the signs and symptoms of this often-fatal disease.

Meningitis can also lead to permanent nerve and brain damage.

All cases of meningitis must be reported to the consultant in communicable disease control (CDC).

Task 1.
Please see your infection control team's policy for the management of meningitis in your Trust. Briefly describe the treatment.

Characteristics of the disease (www.meningitis.org).

	Meningococcal	Pneumococcal	Viral
Causes	Neisseria Meningitis	Streptococcus pneumonaie	Enteroviruses (20% cases) Mumps Herpes
Onset	Gradual – good prognosis	Rapid – can progress to death within a few hours	Gradual
Transmission	Airborne and contact		Faecal /oral route
Other information	3 common strains A, B, C Vaccines are available for A & C Carried in the naso pharynx In 10% of the population	Most serious form of meningitis Usually associated with debilitation e.g. alcoholism	Most common form
Complications	Septicaemia Multi-organ failure Death	Septicaemia Multi-organ failure Death	
Mortality	10% overall	20%	Rarely fatal
Notifiable Disease	Yes	Yes	Yes

The following websites have practical advice, resources and up to date information for health professionals:

www.meningitis-trust.org
www.meningitisuk.org
www.nice.org.uk

Task 2.
Please go to the following web site and look for early red flag symptoms of meningococcal disease. List below.
www.meningitis.org

Task 3.
Now that you have visited the suggested websites, consider the presenting symptoms and discuss the care that a patient may require who is diagnosed with meningitis. Use ABCDE approach.

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Useful websites

www.meningitis.org

www.britishinfectionsociety.org

www.brainandspine.org.uk

www.nice.org.uk

www.epilepsy.org.uk

www.gbs.org.uk

www.meningitis-trust.org

www.meningitisuk.org

Recommended Interactive websites

http://hsc.UWe.ac.uk/neuroanatomy3_6htm

http://.UWe.ac.uk/neuroanatomy1home.htm

http://quizlet.com/1953391/increasing-intercranial-pressureflash-cards/

http://www.youtube.com/watch?V=p-UFLKFxJOAtutorial2

http://www.youtube.com/watch?V=p-UFLKFxJOAtutorial3

http://www.youtube.com/watch?V=p-UFLKFxJOAtutorial9

http://www.youtube.com/watch?V=p-UFLKFxJOAtutorial4

http://www.youtube.com/watch?V=p-UFLKFxJOAtutorial13

http://www.youtube.com/watch?V=p-UFLKFxJOAtutorial28

http://www.palgrave.com/nursinghealth/glasper/skills/resources/ppts/chapter20.pps#476,4,conciousness

?V=E2xzBa00xg&feature=related Pupil response

?V=OyOcazwubau&feature=related Consensual response