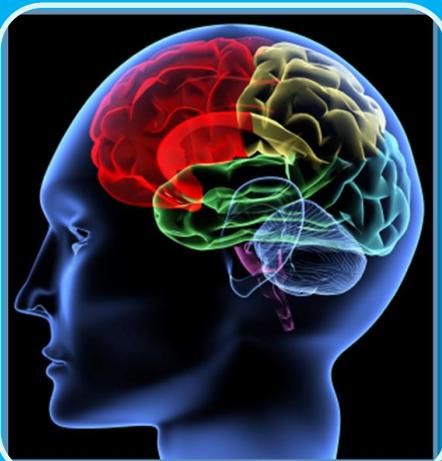


NEUROLOGICAL LEARNING PACKAGE



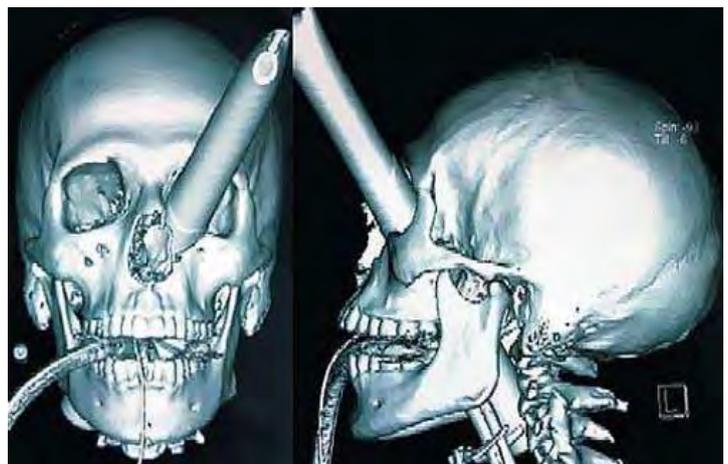
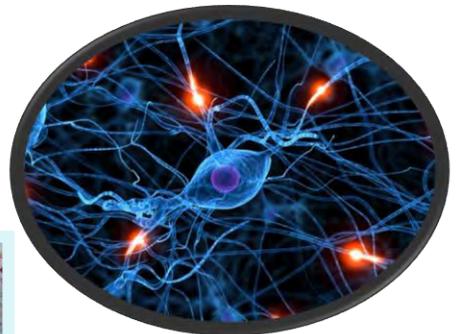
LIVERPOOL ICU
2014



Paula Nekic
CNE

CONTENTS

1. Revision of Anatomy and Physiology
2. Neurological Assessment
3. Injuries to the brain/ Neurological Trauma
4. ICP and EVD monitoring
5. Management of Neurological patient
6. Spinal Management
7. Neurological drugs



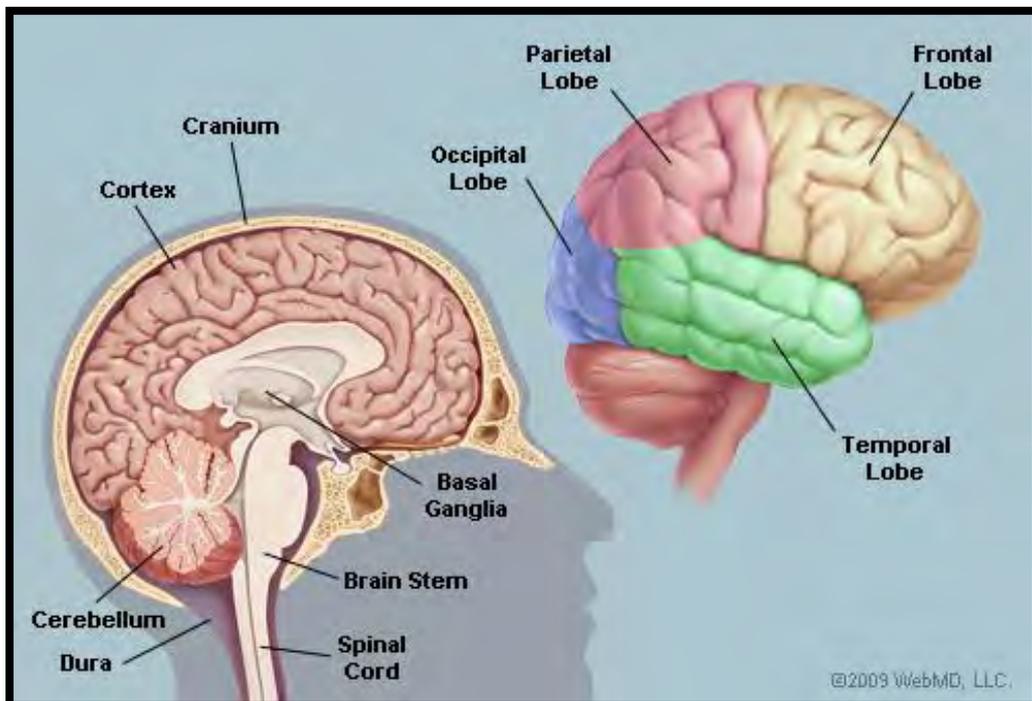
ANATOMY AND PHYSIOLOGY

The brain is one of the largest organs in the body, with a mass of 1300g. It is the centre for everything we feel, decide, remember and coordinates most functions of the rest of the body.

The brain is made up of many cells, but the neurons are the primary players in brain functions. There are 100 Billion [neurons](#) in the brain. A typical neuron has about 1,000 to 10,000 synapses (that is, it communicates with many other neurons, muscle cells, glands, etc.). It has been estimated that there are 1 quadrillion synapses in the human brain.

Neuro anatomy is divided into many areas. This package will be briefly looking at:

- **Brain structures**
- **Vascular system**
- **Meninges**
- **Cranial Nerves**
- **Ventricular system**
- **Reticular Activating System**



BRAIN STRUCTURES:

The brain structure consists of 4 principle parts

1. Cerebrum

- Spreads over the diencephalon like a mushroom cap and occupies most of the cranium
- Cerebral cortex is the outermost layer
- Right and left sides (hemispheres) which are then divided into lobes

Corpus Callosum

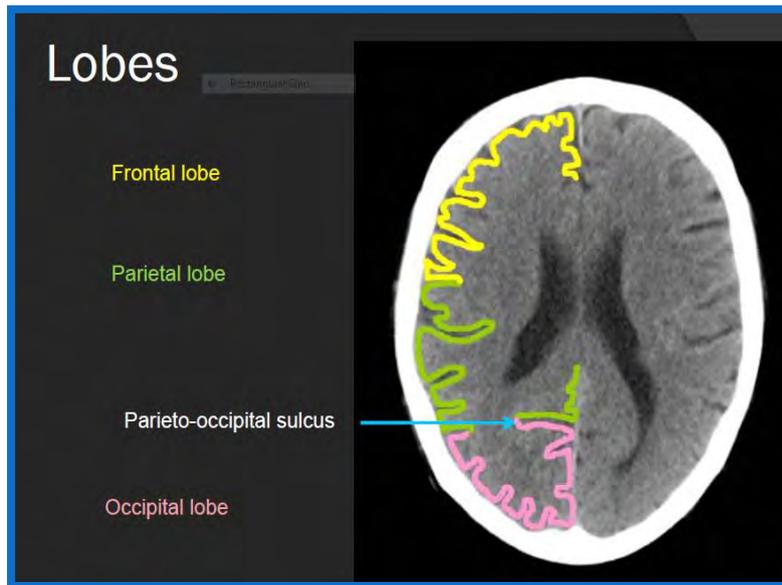
- Connects right and left hemispheres to allow communication between the hemispheres
- Forms roof of lateral and third ventricle

Lobes of the brain

- Frontal
 - Concentration, thoughts, personality, emotions, speech
- Parietal
 - Processes sensory input and sensory discrimination, motor
 - Orientation of self
- Occipital
 - Primary visual reception and association area
 - Allows for visual interpretation
- Temporal
 - Auditory reception and association area
 - Receptive speech (language)
 - Information retrieval (memory)



amazingworldofpsychiatry.com



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2. Diencephalon

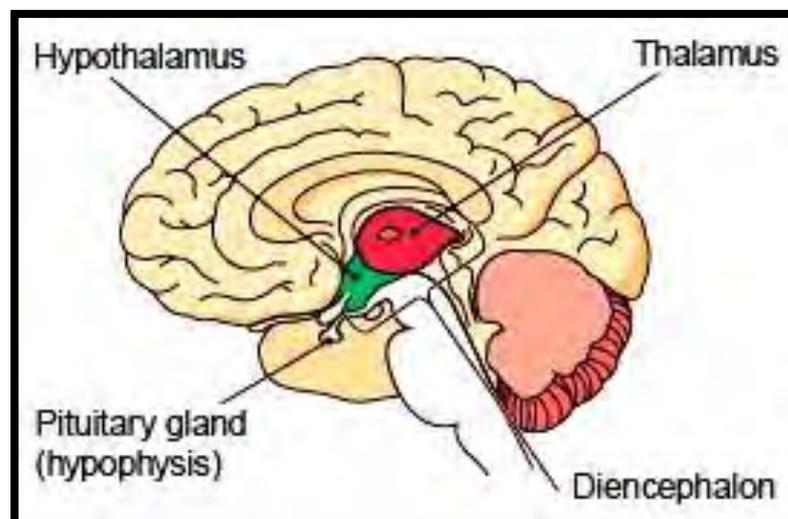
Extends from the brain stem to the cerebrum and surrounds the third ventricle. It includes the:

Thalamus

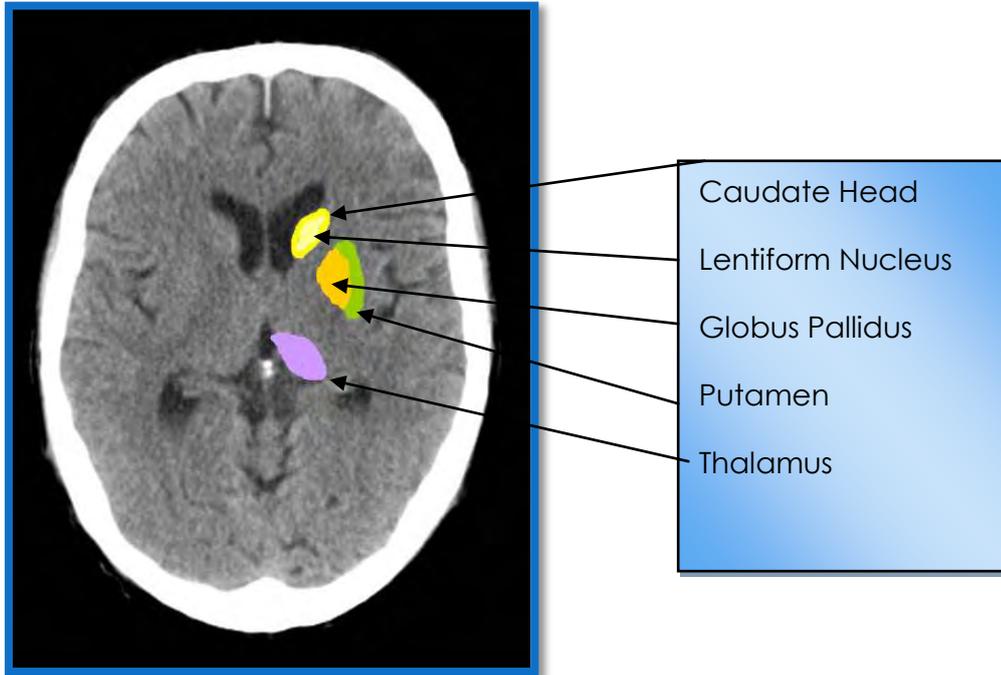
- Involved in sensory perception
- Regulation of motor functions (i.e., movement).
- connects areas of the cerebral cortex that are involved in sensory perception and movement with other parts of the brain and spinal cord that also have a role in sensation and movement

Hypothalamus and pituitary gland

- Controls visceral functions, body temperature and behavioural responses such as feeding, drinking, sexual response, aggression and pleasure.



www.encyclopedia.lubopitko

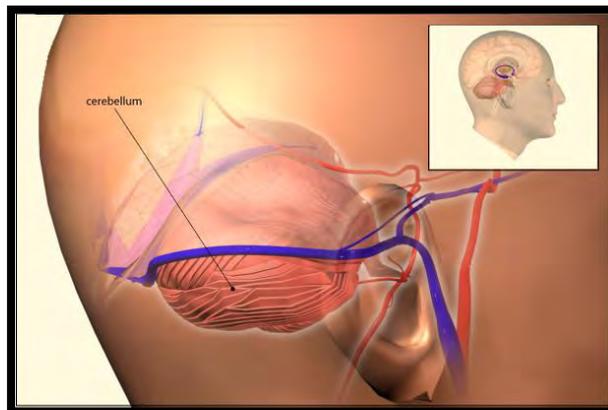


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3. **Cerebellum (little brain)**

The cerebellum is located behind the brain stem and is the second largest part of the brain

- The cerebellum integrates information from the vestibular system that indicates position and movement and uses this information to coordinate balance, posture and limb movements.

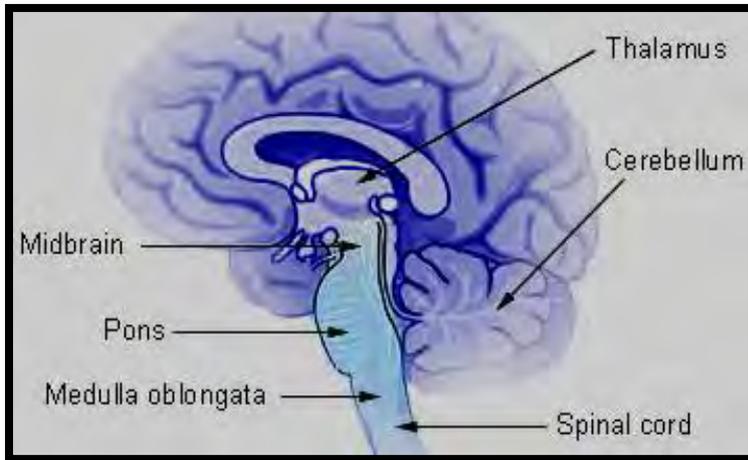


www.grants.hhp.coe.uh.edu



4. Brainstem

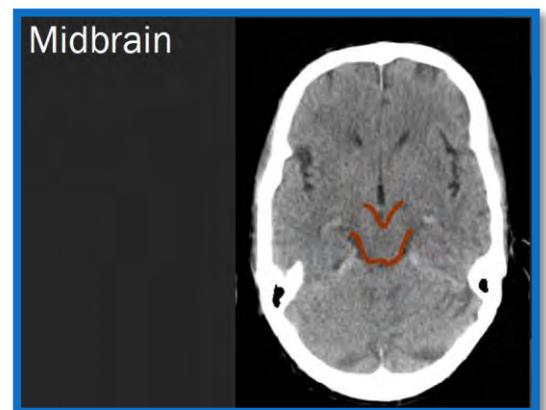
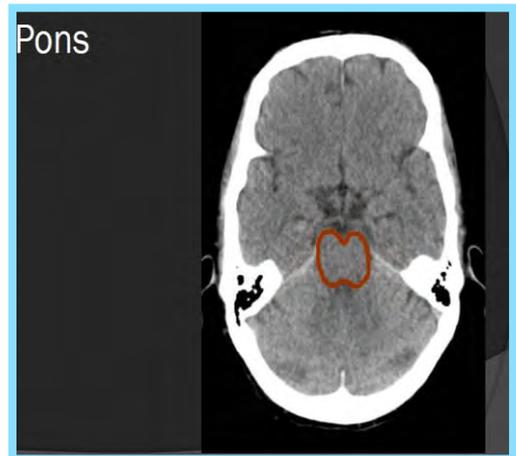
The brainstem connects the brain and the spinal cord.



dmohankumar.com

It consists of:

- The **medulla** (an enlarged portion of the upper spinal cord) and relays motor and sensory impulses between the brain and the spinal cord. Controls the reflexes and automatic functions (heart rate, blood pressure)
- The **Pons** relays impulses from one side of the cerebellum to the other and between the midbrain and the medulla. Helps control breathing
- **Midbrain** relays motor impulses from the cerebral cortex to pons and sensory impulses from the spinal cord to the thalamus. Helps to control limb movements

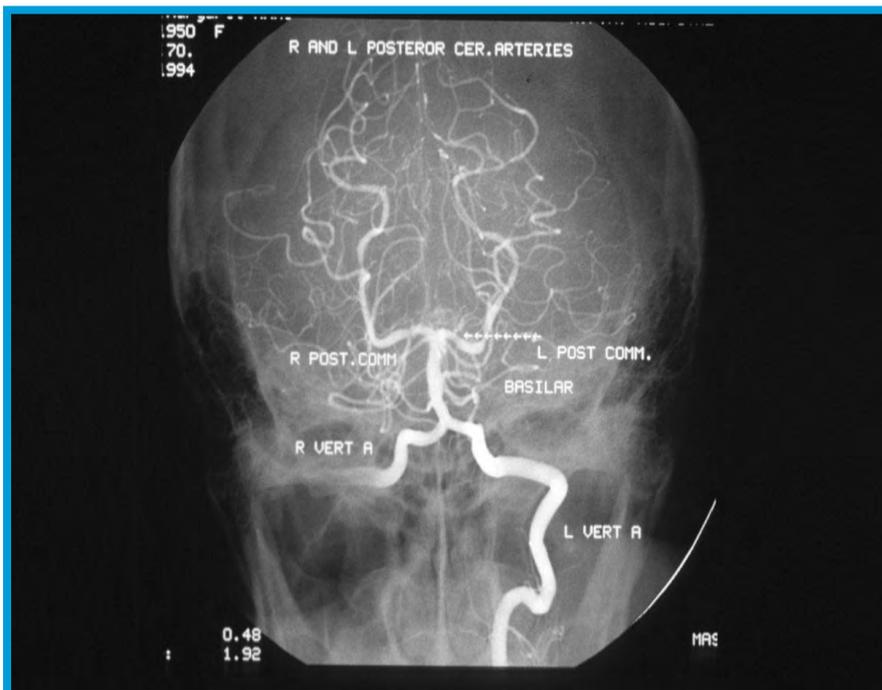
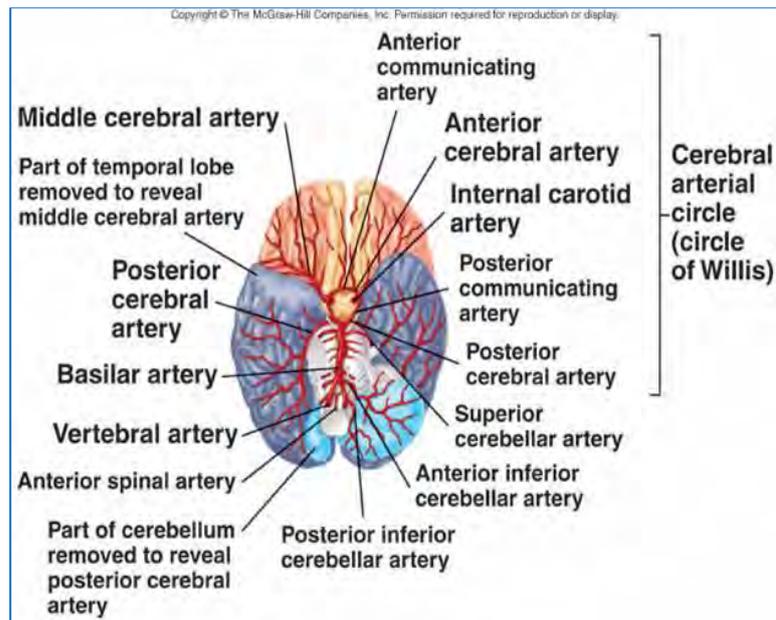


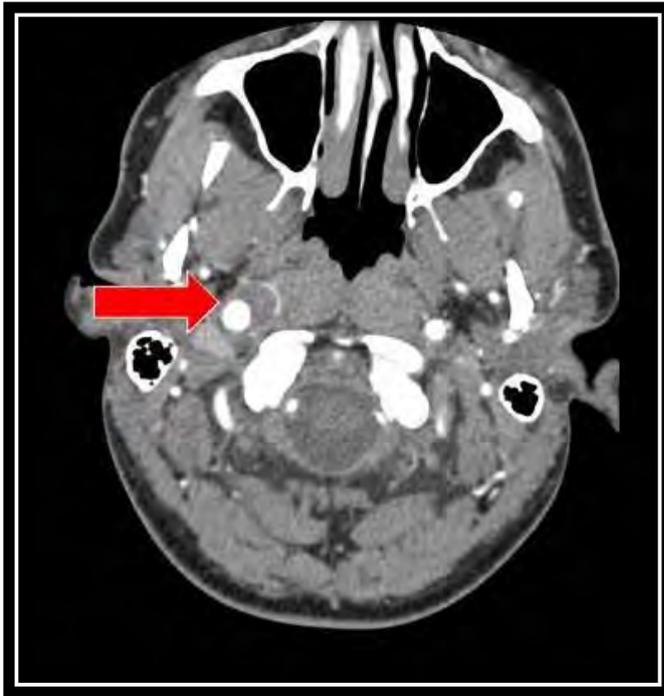
[CEWD Liverpool Hospital: CT Interpretation](#)

VASCULAR SYSTEM

- The internal carotid arteries and the vertebral arteries supply blood to the brain.
- Cerebral blood flow (CBF) comprises 750 millimetres/min of arterial blood
- Main arterial supply subdivides into arterioles and capillaries - highly vulnerable to tissue edema and can thus compromise CBF.
- The circle of Willis is a circle of arteries that gives rise to all the cerebral arteries. It gets its arterial blood from the two internal carotid arteries the two vertebral arteries and basilar artery

rci.rutgers.edu



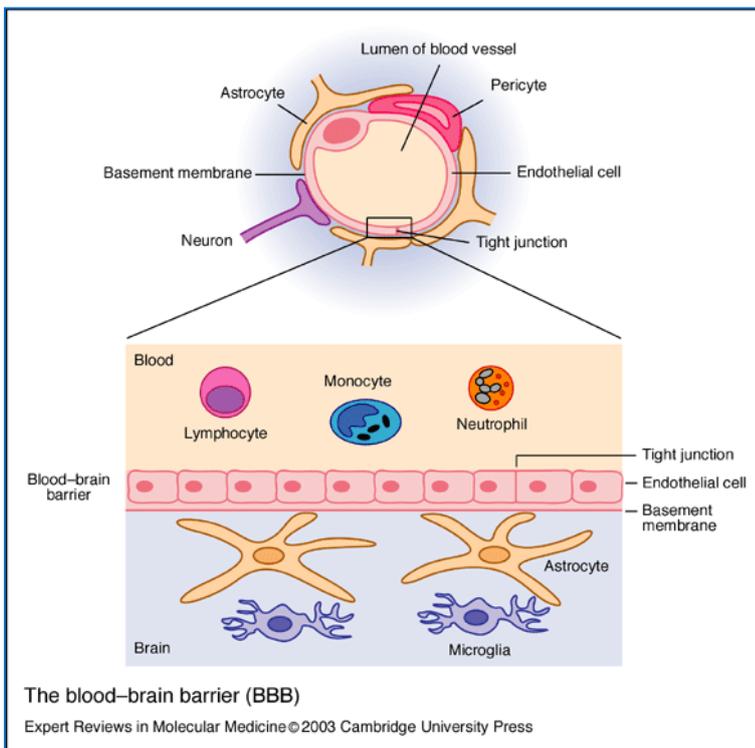


Dilated right internal carotid artery.

radiologycasereports.net

Blood Brain Barrier (BBB)

- The blood brain barrier protects brain cells from harmful substances and pathogens by preventing any passage of many substances from the blood into brain tissue.



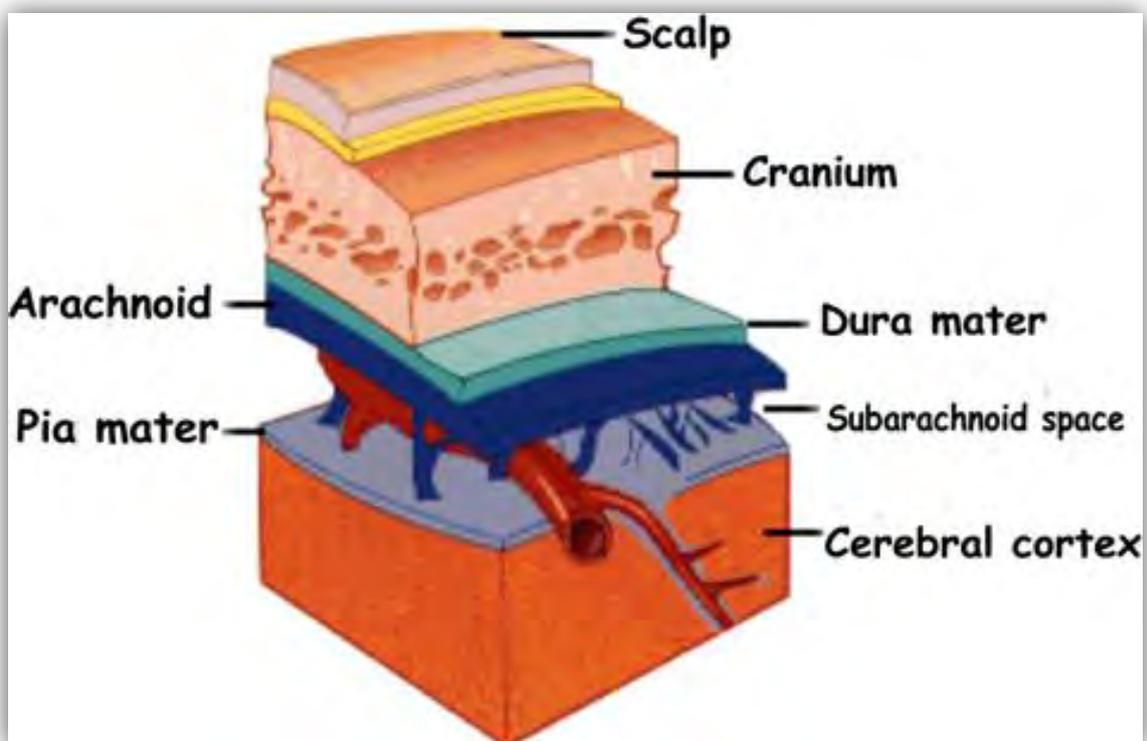
- BBB lets essential metabolites, such as [oxygen](#) and [glucose](#), pass from the blood to the brain and [central nervous system](#)
- Protects the brain from foreign substances such as viruses and bacteria
- Shields the brain from hormones and neurotransmitters in the rest of the body
- Maintains a constant environment for the brain (homeostasis)

MENINGES

The brain is protected by the cranial bones and the cranial meninges.

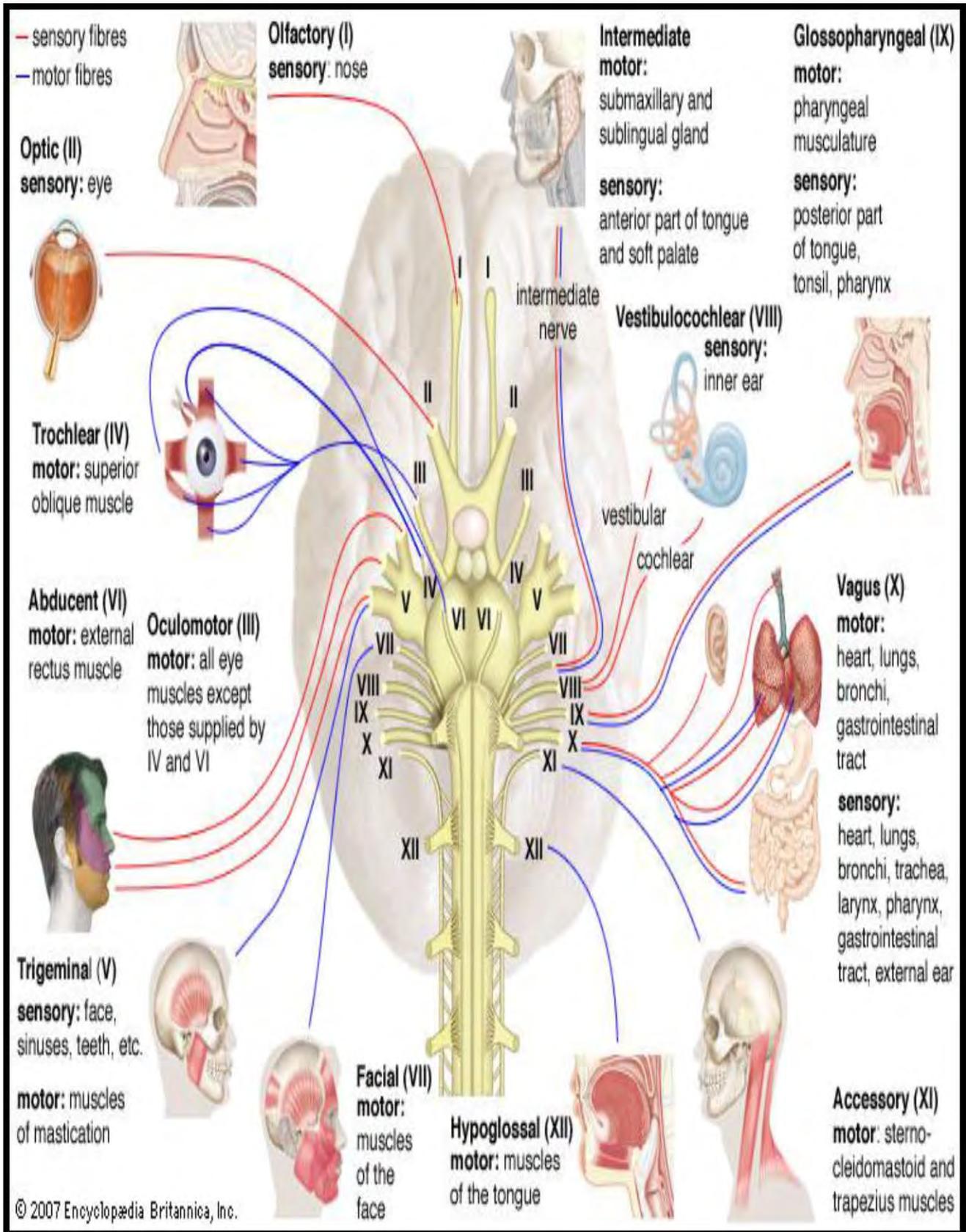
Cranial Meninges

- Continuous with the spinal Meninges
- 3 layers
 - Dura mater (outer layer)
 - Arachnoid (middle layer)
 - Pia mater (inner layer)



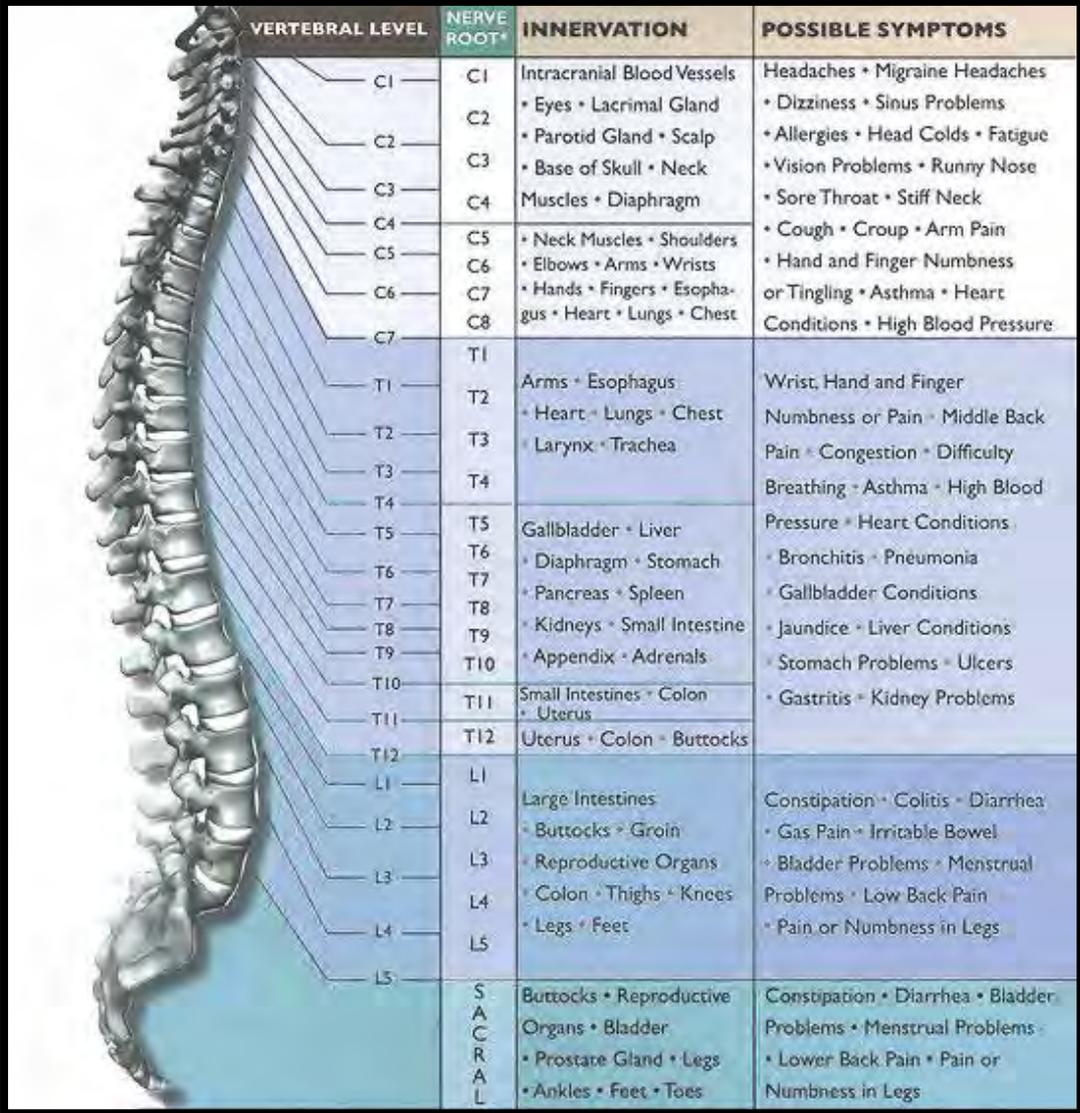
www.the.welingtonneurosurgery.com

CRANIAL NERVES



Spinal Cord

- The spinal cord is the primary pathway for messages travelling between the peripheral areas of the body and the brain.
- It also houses the reflex arc
- Elongated mass of nerve tissue (42-45cms)
- Occupies upper 2/3 of the Spinal canal
- Extends from C1-L1
- The three meninges (dura matter, arachnoid, pia matter) cover the Spinal cord for protection.
- Primary pathway for messages between the brain and the Peripheral areas of the body

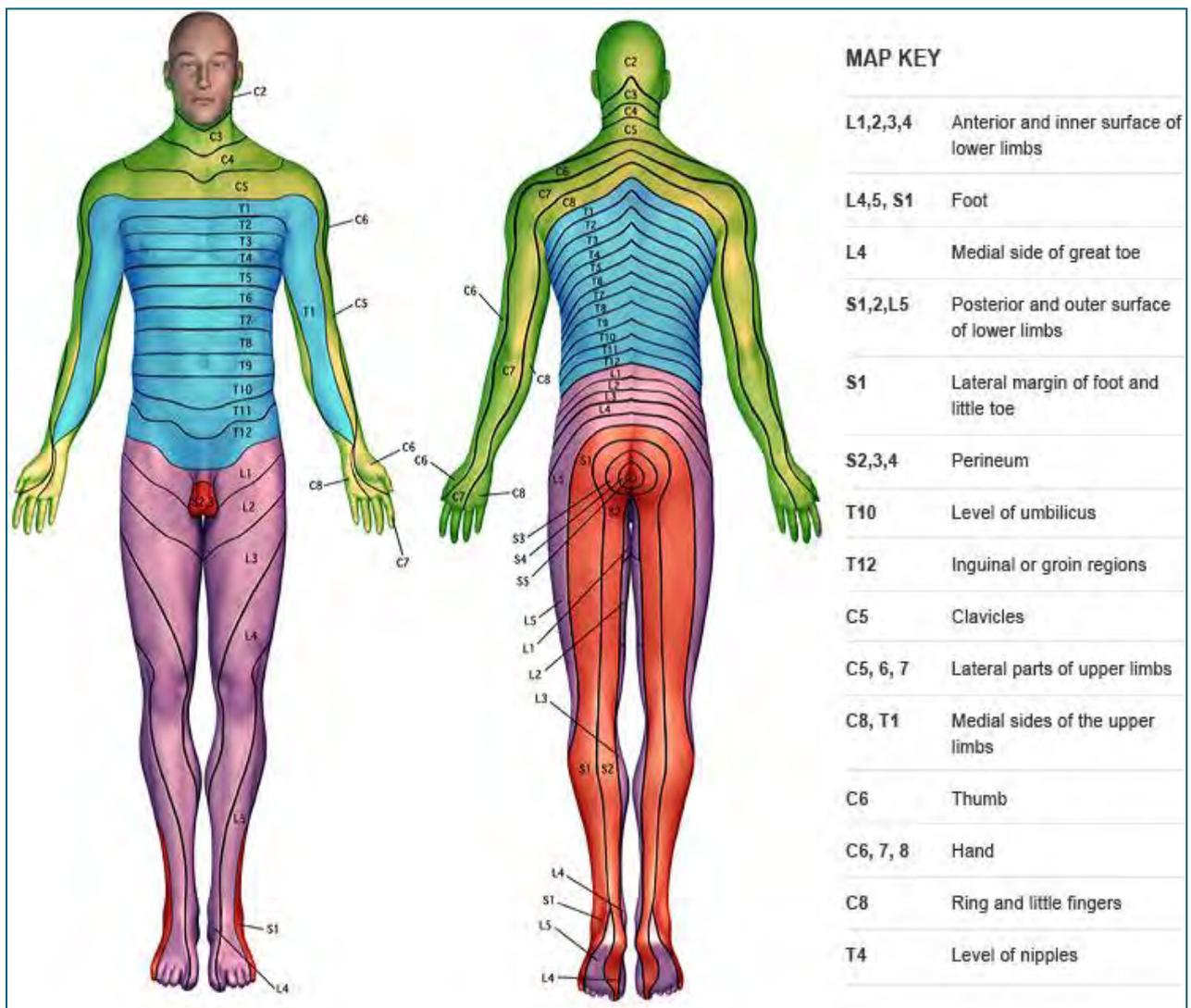


VERTEBRAL LEVEL	NERVE ROOT*	INNERVATION	POSSIBLE SYMPTOMS
C1	C1	Intracranial Blood Vessels	Headaches • Migraine Headaches
C2	C2	• Eyes • Lacrimal Gland	• Dizziness • Sinus Problems
C3	C3	• Parotid Gland • Scalp	• Allergies • Head Colds • Fatigue
C4	C4	• Base of Skull • Neck	• Vision Problems • Runny Nose
C5	C5	Muscles • Diaphragm	• Sore Throat • Stiff Neck
C6	C6	• Neck Muscles • Shoulders	• Cough • Croup • Arm Pain
C7	C7	• Elbows • Arms • Wrists	• Hand and Finger Numbness
C8	C8	• Hands • Fingers • Esophagus • Heart • Lungs • Chest	or Tingling • Asthma • Heart Conditions • High Blood Pressure
T1	T1	Arms • Esophagus	Wrist, Hand and Finger
T2	T2	• Heart • Lungs • Chest	Numbness or Pain • Middle Back
T3	T3	• Larynx • Trachea	Pain • Congestion • Difficulty
T4	T4		Breathing • Asthma • High Blood
T5	T5	Gallbladder • Liver	Pressure • Heart Conditions
T6	T6	• Diaphragm • Stomach	• Bronchitis • Pneumonia
T7	T7	• Pancreas • Spleen	• Gallbladder Conditions
T8	T8	• Kidneys • Small Intestine	• Jaundice • Liver Conditions
T9	T9	• Appendix • Adrenals	• Stomach Problems • Ulcers
T10	T10	Small Intestines • Colon	• Gastritis • Kidney Problems
T11	T11	• Uterus	
T12	T12	Uterus • Colon • Buttocks	
L1	L1	Large Intestines	Constipation • Colitis • Diarrhea
L2	L2	• Buttocks • Groin	• Gas Pain • Irritable Bowel
L3	L3	• Reproductive Organs	• Bladder Problems • Menstrual
L4	L4	• Colon • Thighs • Knees	Problems • Low Back Pain
L5	L5	• Legs • Feet	• Pain or Numbness in Legs
SACRAL	SACRAL	Buttocks • Reproductive Organs • Bladder • Prostate Gland • Legs • Ankles • Feet • Toes	Constipation • Diarrhea • Bladder Problems • Menstrual Problems • Lower Back Pain • Pain or Numbness in Legs

thespineclinic.com

Dermatomes

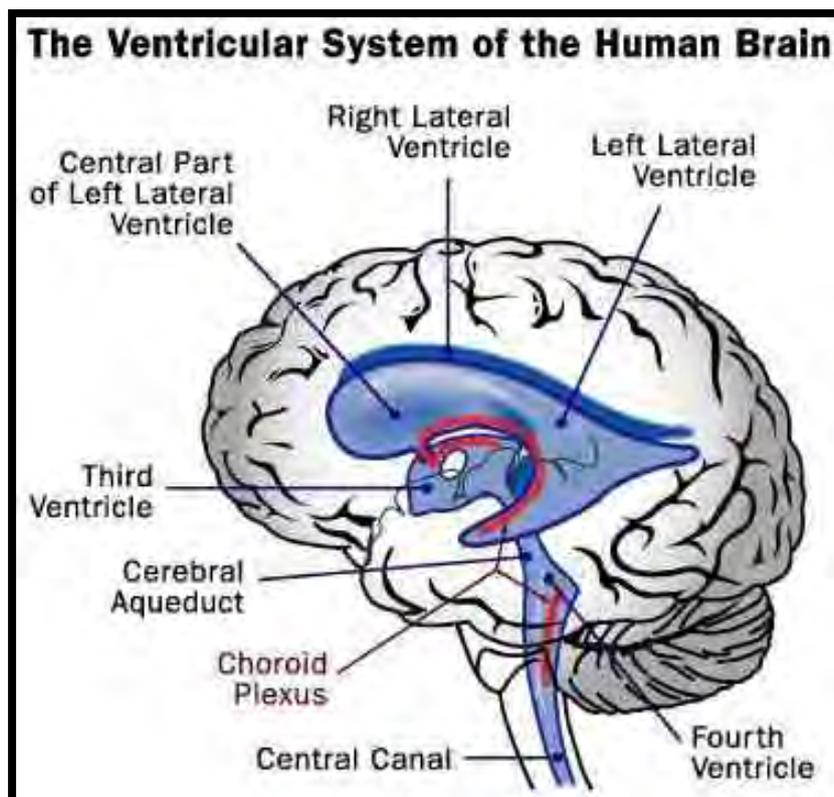
- Each of the spinal nerves exits the spinal canal between two of the vertebra.
- Each then goes to a particular area of the body.
- The area of skin served by each of these nerves is called its dermatome
- The nerves from the upper cervical spine serve the skin of the neck.
- The nerves from C5 to T1 (the mid-cervical spine to the upper thoracic spine) go to the arms.
- The nerves from T2 to L2 (thoracic to upper lumbar) go to the chest and abdomen.
- Those from L3 to S1 (lumbar and the first sacral) go to the skin of the legs.
- The remainder of the sacral nerves, and the coccygeal nerves, go to the groin.



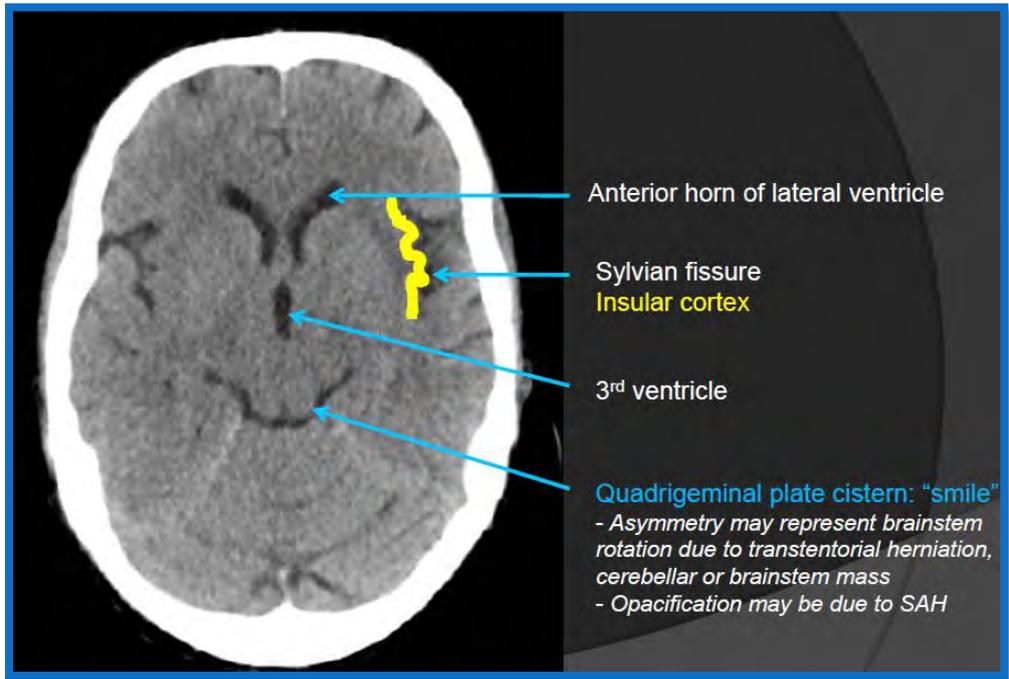
lumbarspinalstenosis.com

VENTRICULAR SYSTEM

- CSF fills the ventricles of the brain and the subarachnoid space of the brain and spinal cord.
- It acts as a "cushion" or buffer for the cortex, providing a basic mechanical and immunological protection to the brain inside the skull.
- It is produced in the choroid plexus
- Produced by the Choroid Plexus in the 2 *Lateral Ventricles*.
- Flows via the Foramen of Monro into the *3rd Ventricle*.
- Flows via the Cerebral Aqueduct into the *4th Ventricle*.
- At this point CSF flows through the 2 *Lateral Foramen of Luschka & Foramen of Magendie* via the Cisterna Magendie into the Subarachnoid space.
- It is absorbed by the Arachnoid Villi in the subarachnoid space into the Superior Sagittal Sinus where it then enters the Venous System.



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Intra Cranial Pressure (ICP)

- ICP is the pressure exerted within the skull by the brain tissue, blood and CSF.
- Normal ICP is estimated to range from 0 – 15mmHg.
- Cerebral perfusion pressure (CPP) is the perfusion pressure needed to provide optimal blood flow & adequate O₂ and nutrients to the cerebral tissue.
- It is the difference between arterial flow in to the brain and venous flow out. Hence, cerebral perfusion pressure may be calculated using the following equation (Steiner & Andrews, 2006):

$$\text{CPP} = \text{MAP} - \text{ICP}.$$

E.g.: if MAP is 90 & ICP is 20,
then CPP = 90-20 = 70

Therefore, the rate of blood flow to the brain is critically dependent on:

- Mean arterial pressure (MAP), and
- Intracranial pressure (ICP).

Cerebral perfusion pressure must be maintained within narrow limits to prevent secondary brain injury.

- If CPP is low (<50 mmHg) hypoperfusion and ischaemia of the brain can result.
- If CPP is high (>150 mmHg) cerebral oedema and hypertensive encephalopathy can result.

Indications for monitoring ICP

- To provide information of actual or possible ↑ ICP
- Provides information about CPP and hence cerebral blood flow
- To anticipate possible cerebral tissue ischemia caused by ↑ ICP and compromised blood flow
- As a diagnostic tool



Codman ICP monitor

Cerebral autoregulation and compensatory mechanisms

Brain activity requires a constant flow of blood. This is achieved by maintenance of:

- Cerebral blood flow (CBF).
- Cerebral perfusion (CPP).
- Intracranial pressure (ICP).

The brain's ability to maintain a constant cerebral blood flow despite changes in perfusion pressure is called **cerebral autoregulation**. This is done in response to:

- Intrinsic factors – levels of oxygen, carbon-dioxide and hydrogen ion can change the flow of blood through the brain vessels through vasoconstriction and vasodilatation.
 - ↑ CO₂ → vasodilatation.
 - ↓ CO₂ → vasoconstriction.
- Extrinsic factors – changes in systolic BP. This only works to a certain point; once the mean arterial pressure goes outside 60–150 mmHg, autoregulation fails and small changes make big differences to cerebral blood flow.

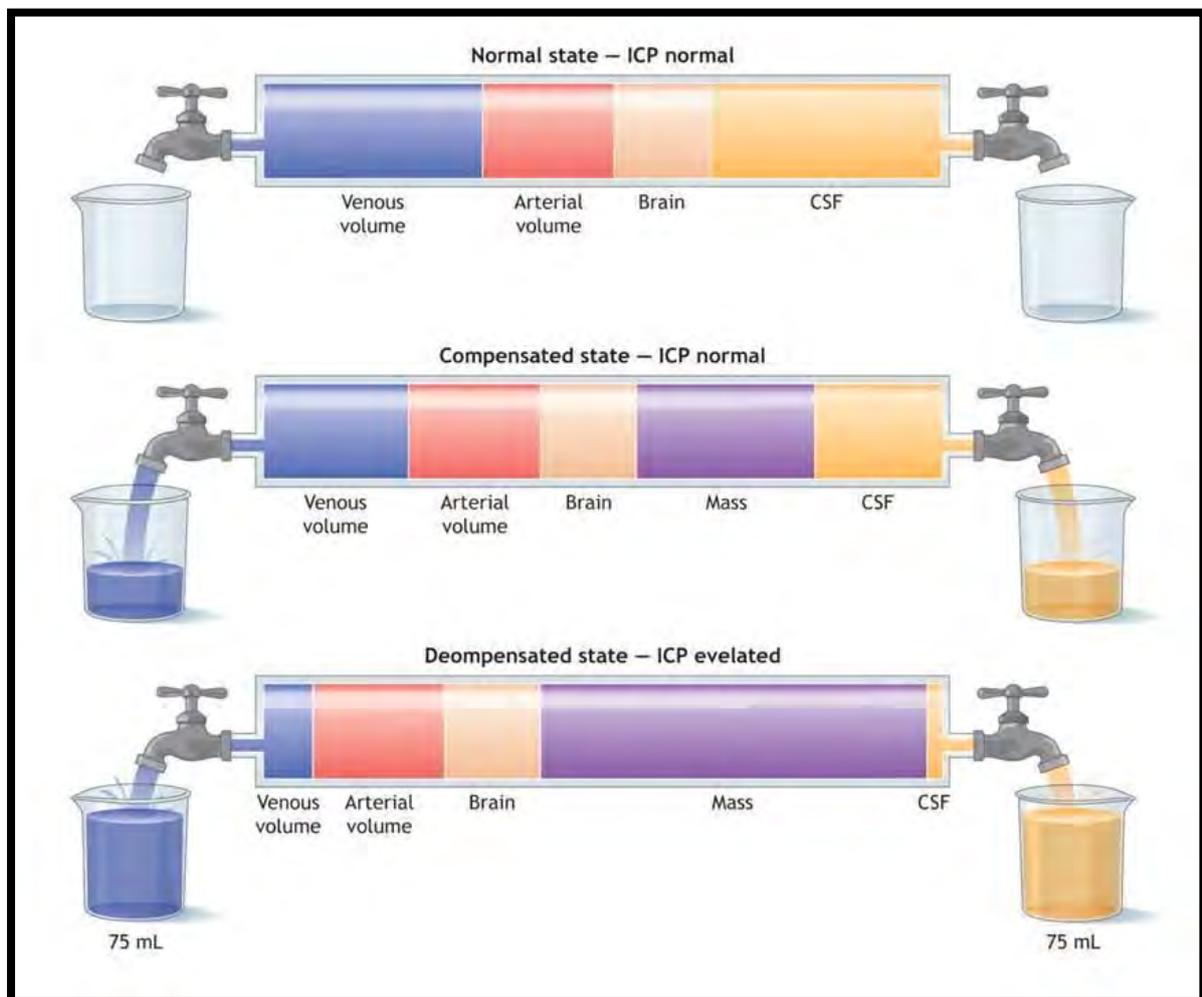
If the body is unable to compensate, the following can occur:

- Cerebral oedema.
- Hydrocephalus – dilatation of the venous system when CSF production exceeds the absorption rate.
- Intracranial hypertension.
- Herniation or 'coning'.

Monro – Kellie Hypothesis

- The skull is a rigid vault with three components, namely brain matter (80%), CSF (10%) and cerebral blood (10%).
- An increase in volume of any one of these will result in a concomitant decrease in volume of one or both of the remaining components in order for overall volume to remain constant: or else ICP will rise.

- That is, if there is raised ICP the body will try to compensate by decreasing the volume. There are several different ways that this can occur:
- Displacement of CSF from the cranial subarachnoid space and basilar cisterns to the spinal subarachnoid space and lumbar cisterns
 - ↓ production of CSF by the choroid plexus
 - ↑ Absorption of CSF by the arachnoid villi occurs as ICP rises.
 - Reduction in cerebral blood volume by shunting of venous blood away from the affected area into the distant venous sinuses in response to ↑ ICP.
 - This can however result in ↓ cerebral blood flow and CPP with resulting 2° brain injury and cerebral ischemia



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Elastance and compliance

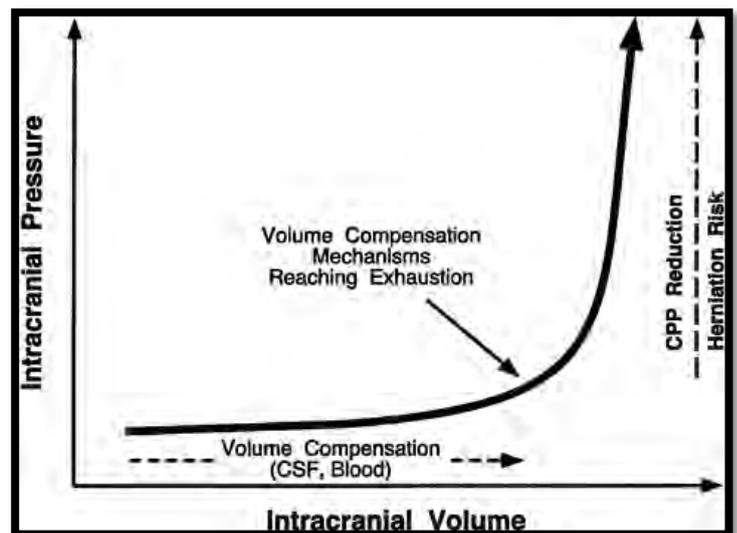
- Elastance and compliance govern the compensatory ability of the brain and thus regulate the volume pressure relationship and the limits of compensation.
- Elastance (stiffness of brain) is the unit change in pressure for a given change in volume = P / V .
 - High elastance results in large \uparrow in pressure for small \uparrow in volume.
- Compliance (slackness of brain) is the unit change in volume for a given change in pressure = V / P .
 - Low compliance results in large \uparrow in pressure for small \uparrow in volume.
- Therefore low compliance or high elastance results in loss of compensation and \uparrow ICP.

Intracranial compliance curve (ICC) ¹⁹

ICC demonstrates the volume – pressure relationship and the compensation that results among the brain tissue, blood & CSF to accommodate for alterations in intracranial contents

The plateau phase occurring at low volumes reveals that the intracranial space is not completely closed, and there is some compensatory latitude.

- Compensation is accomplished principally by the translocation of cerebrospinal fluid (CSF) and venous blood to the spinal CSF space and to extracranial veins, respectively.
- Ultimately, when the compensatory potential is exhausted, even tiny increments in the volume of the intracranial contents can result in substantial ICP increases.
- These increases have the potential to result in either herniation of brain tissue from one compartment to another (or into the surgical field).



web.squ.edu.om

Reticular Activating System (RAS)

- Is a loose network of neurons and fibres in the brainstem which receive input from spinothalamic (sensory) pathways and project to the entire cerebral cortex.
- **Arousal**
 - Is dependent on the adequate functioning of the RAS.
 - Is purely a function of the brain stem.
 - It does not have anything to do with the thinking parts of the brain.
 - The fact that your patient opens his/her eyes when you call their name is an indication that their RAS (brainstem) functioning is intact but it does not tell you if they are awake or aware.
- **Cortex**
 - Modulates incoming information via connections to the RAS.
 - Therefore, the cortex requires functioning of the RAS to function itself.
- **Awareness**
 - Means that the cerebral cortex is working and that the patient can interact with and interpret his environment.
 - We evaluate awareness in many ways but tend to focus on four areas of cortical functioning: orientation, attention span, language, and memory.²

NEUROLOGICAL ASSESSMENT

Evaluation of neurological status and level of consciousness is an essential part of nursing at the critical care level. Regardless of diagnosis, patients can experience neurological deficits and changes in mental status based on their current condition, medication regime or acute changes in their overall condition. The recognition of a change in mental status can make a significant impact on a patient's prognosis. Early identification of neurological deterioration is vital to preventing secondary brain injury¹

Physical assessment

A complete neurologic assessment consists of the following steps:

- ✚ Interview
- ✚ Level of consciousness/Mental status exam
- ✚ Motor system assessment
- ✚ Pupillary assessment
- ✚ Cranial nerve assessment
- ✚ Reflex assessment
- ✚ Sensory system assessment
- ✚ Cerebral function

Interview:

A health history of the patient will help you to gather

- data: both subjective and objective about the patient's previous/present health state
- provide information to patient/family
- develop a good working relationship with both the patient and the family
- information about patients signs and symptoms such as:
 - ❖ headache
 - ❖ difficulty with speech
 - ❖ inability to read or write
 - ❖ alteration in memory
 - ❖ altered consciousness
 - ❖ confusion or change in thinking
 - ❖ disorientation
 - ❖ decrease in sensation, tingling or pain
 - ❖ motor weakness or decreased strength
 - ❖ decreased sense of smell or taste
 - ❖ change in vision or diplopia
 - ❖ difficulty with swallowing
 - ❖ decreased hearing
 - ❖ difficulty with swallowing
 - ❖ altered gait or balance
 - ❖ dizziness
 - ❖ tremors, twitches or increased tone²

Level of consciousness

(Adapted: Neurological Assessment Guideline using the Glasgow Coma Scale (GCS) SSWAHS Corporate Manuel 2008)

Consciousness (a state of awareness of oneself and the environment) is the most sensitive indicator of neurological change.

- **Arousal** - the patient's wakefulness (brainstem).
- **Awareness** - the `thinking' aspect (cerebral cortex).
- The tool to assess level of consciousness is the Glasgow Coma Scale (GCS)
- The GCS is a 3-15-point scoring system designed to objectively assess cerebral function in conjunction with pupillary function and limb strength assessment

- To assess degrees of coma/ consciousness, three aspects of functioning are considered:
 1. Eye-opening.
 2. Verbal response.
 3. Motor movement.
 - These are collectively attributed a score out of 15.
 - These areas of assessment correspond to the complex organisation of the sensory/motor cortex, functions of the lobes of the brain and the brainstem

- Additional assessment is made of:
 - Limb strength
 - Pupillary size, equality and reaction
 - Haemodynamic status - BP, Heart Rate, Temperature, SpO₂, respiratory rate and end-tidal CO₂

The assessment is carried out in 3 stages:

Eye opening, Verbal response and motor response

EYE OPENING	VERBAL RESPONSE	BEST MOTOR RESPONSE
4 Spontaneous	5 Orientated	6 Obeys
3 To speech	4 Confused (conversation)	5 Localises
2 To pain	3 Inappropriate (words)	4 Withdraws
1 None	2 Incomprehensible (sounds)	3 Abnormal (spastic) Flexion
	1 None	2 Extension
		1 None

Sequence to follow for Stimulation

1. Speak, and then shout
2. Shout and shake
3. Use of pain/noxious stimulus
4. Score the best response

EYE OPENING

- If the patient is awake (eyes open) and cooperative (able to follow directions/commands) and is unable to move a limb, there is no need to then use painful stimulus – assess patient for damage to their motor pathways.

- As patient advocates it is imperative that we inform our patients/carers of the necessity for these forms of observations. Explain that the use of deep pain to elicit a movement may be unpleasant but accurate assessment is essential.

- Credence must be given to observations that the family may make about the patient's level of consciousness. When a close relative/carer asserts that the patient is "not as good as they were", it is important to investigate their observation.

4 - Open spontaneously

- The eyes are open without stimulation, indicating that the arousal mechanisms of the reticular activating system (in the brainstem and hypothalamus) are active.

3 - To speech

- The patient responds to voice by opening their eyes. A normal voice level is used but, if insufficient, greater verbal stimulus may be required. A louder voice must be used for those patients with impaired hearing.
- Touch and shake are not listed on the chart but the patient's response to these must be assessed before progressing to the use of painful stimulus.
- Frequently, patients are sleep deprived and will respond to shaking without the use of pain. This may then be scored as 'eyes open to speech'.
- If the patient's condition then deteriorates and noxious/painful stimulus is used to obtain an eye-opening response, then this deterioration can be accurately assessed/noted/addressed.

2 - To pain

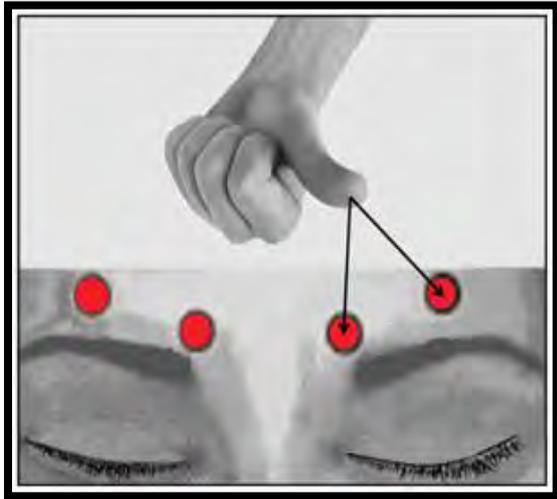
- If the patient is unable to respond as above, then noxious/painful stimulation must be used to elicit a response.
- Central pain is used first to assess cerebral response.
- Peripheral pain may be used to assess 'eye opening' but is avoided for assessing motor response as a first-line assessment as it may elicit a reflex response (spinal), which does not assess cerebral function.

1 - Nil eye opening

- If the patient does not respond to painful stimulation then they are given a score of 1.
- If the eye is swollen from trauma or surgery then the letter "C" is recorded, denoting 'closed'.
- If pharmacological paralysis or deep sedation is utilised, "P" or "S" is written in the box or "Paralysed" / "Sedated" is recorded across the 'Coma Scales' area. No score is given.

Three Types of Central Stimulus:

- Supra-orbital pressure
- Trapezius pinch
- Sternal rub

Supra-orbital pain

- Is applied by placing the thumb parallel to the indentation found on the eyebrow ridge nearest the nose.
- The supra-orbital nerve plexus is stimulated by strong pressure. This stimulus is inappropriate when there is known or suspected damage to the orbital structure or where local facial fractures are present. It is not used to assess the 'eye-opening' response, as a normal response to this form of stimulus is to grimace and shut the eye

The Trapezium pinch

- Is applied by gathering the fold of skin and muscle above the collarbone (closest to the neck) and squeezing firmly.
- It is best used on patients who have a defined neck.
- On patients with short or very muscular neck/shoulders it may be difficult to apply a strong pressure to elicit a response.



- When assessing for movement, try both Trapezius muscles to obtain the best motor movement, rotate sites between assessments to avoid localised damage.

The Sternal rub

- Is rarely appropriate and can cause serious tissue damage.

Other types of noxious stimuli

- Patients may move spontaneously but fail to respond to deep central pain. In these instances, peripheral pain may be used on the upper extremities to elicit movement. Caution must be taken with the elicited response as it may be a reflex and thus bears no relevance to assessing the patient's cerebral function.
- Peripheral stimuli that may be used include (a) pressure to the side of the finger, next to the nail or (b) pinching of the fine skin over the triceps muscle.
- Consideration of what is an appropriate form of noxious, painful stimuli is the concern of the nurse and doctor caring for the patient.
- There is no evidence of the validity of using nipple twists or genital pain as an appropriate painful stimulus; they should never be used.

VERBAL RESPONSE

- Verbal response assesses two key elements:
 - Comprehension and transmission of sensory input; verbal or physical.
 - Ability to articulate or express a reply.
- These areas focus on four aspects of cortical functioning:
 - Orientation,
 - Attention span,
 - Language, and
 - Memory.
- Deficits involving these areas will result in a decreased GCS – verbal response.

5 - Orientated

- The patient is asked questions to assess if they are orientated to time, place and person. This corresponds to the patient's short, mid and long term memory. They should know what day, month and year it is; where they are and who they are.
- Caution: some cultural groups may not consider age or time as important issues; ask alternate questions. Being able to identify familiar faces or 'known' facts is important.
- It may be necessary to inform the patient of the day and specifically request that they remember the day and date. This will also assess their short-term memory. Known facts are: e.g. Doctors and nurses work in hospitals.

4 - Confused

- The patient is unable to correctly identify one or more of the above areas despite correcting the wrong response. If the patient has a pre-existing dementia then they are still scored as confused. Obvious reasons for confusion, such as hypoxia, are addressed immediately.
- The confused person speaks in sentences. They may be able to respond in a conversational manner but responses are incorrect.

3 - Inappropriate

- The patient responds to the spoken word (and possibly to their environment) inappropriately. They are often unable to hold a conversation or will respond to questions in an unrelated manner - e.g. "Who is the Prime Minister?" may be answered with "I did the shopping". Often words rather than sentences are used and these may be obscenities.

2 - Incomprehensible

- Words are unable to be distinguished from sounds made in response to questions or to painful stimuli. Moaning or groaning is heard.

1 - No verbal response

- There is no verbal response.
- If a patient is intubated or has a cuffed tracheostomy tube insitu preventing speech, then a "T" is recorded in the 'No Response' area. This is still scored as one point.
- If the patient is able to write, this can be noted in the comments section – they are still scored '1' – for no verbal response

Motor System Assessment

BEST MOTOR RESPONSE**6 - Obeys Commands**

- The patient is able to follow verbal or signalled direction by moving their limbs in a purposeful manner. Questions such as "Lift your arm/leg off the bed" are useful because they can differentiate from coincidental movement.
- If the patient has a known gross limb weakness/paresis/plegia then ask the patient to poke their tongue out. Wriggling fingers/toes is a useful request for patients with generalised weakness.

5 - Localises

- If the patient is unable to obey commands then the assessor must use a central stimulus to elicit a response. The best response is then recorded. E.g. if the arms flex and the legs extend, then flexion is the best response.
- During central pain/noxious stimulus, the assessor watches for the patient to attempt to locate and remove the stimulus (a 'localising' or purposeful response).
- If the patient attempts to remove the stimulus ineffectively but is able to move their arm(s) at or above the nipple line, it is classified as a localising response - albeit a poor one

4 - Withdraws (Normal Flexion)

- The patient responds to painful stimulus by trying to withdraw away from the source of the pain.
- It is termed a 'withdrawal flexion' and differs from "spastic" abnormal flexion.
- Withdrawal response is characterised as a normal flexion of the elbow with the arm moving away from the body. There is no purposeful movement to remove stimuli. There is no stiffness associated with the movement and it may be accompanied by a grimace or frown. Occasionally the patient's body may attempt to move away from the source of pain.

3 - Abnormal Flexion (Spastic Flexion)

- There is increased tone with a reflex-like response to pain.
- Movement is generally slow, the forearm and hand are held close into the body. The elbow flexes rigidly.
- This form of movement can result in increased expenditure of energy due to the muscle spasm/rigidity.
- Legs are not assessed for 'flexing' as bending the knees and flexing are indistinguishable.

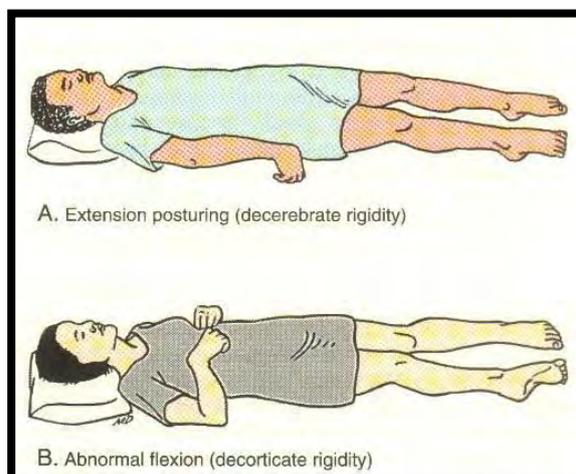
2 - Extension

- This indicates a brainstem (poor) response.
- The arms, if extending, will be close to the body and rigidly straightened with fists rotating into the body.
- Legs are straightened with the feet pointing downwards.
- This posture expends much energy, increasing body temperature and oxygen consumption. It will increase intracranial pressure (ICP) in compromised patients and if it persists, must be treated.

1 - No movement

- There is no visible trace of muscle movement or contraction in response to deep central pain (nor to peripheral stimulus).

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Additional assessment

- Limb strength
- Pupillary size, equality and reaction

LIMB STRENGTH

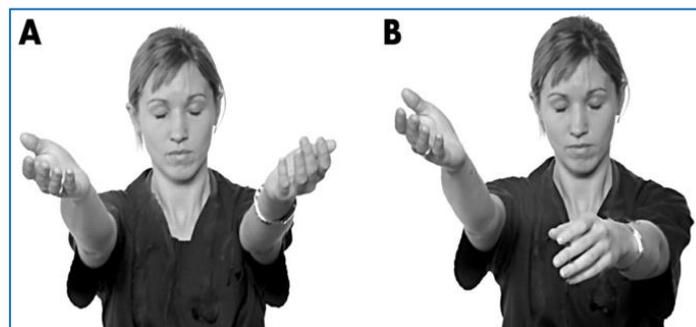
Assessment is based upon NHMRC grading:

- **5** -Full ROM against gravity and resistance; normal muscle strength
 - **4** -Full ROM against gravity and a moderate amount of resistance; slight weakness
 - **3** -Full ROM against gravity only, moderate muscle weakness
 - **2** - Full range of motion when gravity is eliminated, severe weakness
 - **1** -A weak muscle contraction is palpated, but no movement is noted, very severe weakness
- Testing the upper limbs, then lower limbs simultaneously, assesses equality of movement. Patients are asked if their limb movements feel equal.
 - When a person is unable to obey commands but moves limbs to pain, then limb strength is based upon the degree of movement as specified above.
 - If the patient is able to obey commands but cannot move a limb – do not use painful stimulus to effect a movement. Investigate for causes of hemiparesis/hemiplegia

Pronator Drift is another means to assess for arm weakness

- The patient is requested to close their eyes and stretch their arms out as in holding a bowl of soup.
- Closing the eyes is imperative to prevent visual correction of the arm's position. Weakness (or an inattention to that side of the body) is evidenced by:
 - Arm trembling
 - Hand pronating (turning downwards)
 - The arm drifting down towards the body

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Pupillary Assessment

- Assesses the size, equality, reaction to light and consensuality of pupil response.
- **Size**
 - Pupils are assessed for size against a uniform scale in millimetres. Differences are noted between the pupils.
- **Equality**
 - An unequal pupil may indicate increasing pressure on the Oculomotor nerve (unilateral side) or indicate ischaemia of the brainstem.
 - One in five people have naturally occurring unequal pupils. Therefore, it is essential to evaluate the GCS in conjunction with assessment of the pupils.
- **Reaction**
 - Direct a small, bright torch from the side of the face to shine into the eye.
 - Pupillary response is recorded as brisk, sluggish or non-reactive.
 - If the response is difficult to see the surroundings should be dimmed.
 - Changes are significant when accompanied by a decrease in the patient's neurological response.

Reactions are recorded as:

- "+" for a brisk response;
 - "o" for a sluggish response
 - "-" for no response.
- **Consensuality** - when testing pupillary response in the cooperative patient, a light shone into one eye should stimulate both pupils to constrict.

Issues in Pupillary Assessment:

- Lack of reaction or decreased response may be due to increased ICP, hypoxia or drug therapies.
- Narcotics such as morphine or fentanyl will constrict the pupil, atropine will dilate the pupil and barbiturates such as thiopentone will make the response sluggish; in high doses the response will disappear.
- Vigilance in assessment of the pupils in conjunction with the Glasgow Coma Score will alert the assessor to neurological deterioration.

Cranial Nerve Assessment

Cranial Nerve		Function	Method	Normal Findings
I	Olfactory	Smell reception and interpretation	Ask patient to close eyes and identify different mild aromas such alcohol, powder and vinegar.	Patient should be able to distinguish different smells
II	Optic	Visual acuity and fields	Ask patient to read newsprint and determine objects about 20 ft. away	Patient should be able to read newsprint and determine far objects
III	Oculomotor	Extraocular eye movements, lid elevation, papillary constrictions lens shape	Assess ocular movements and pupil reaction	Patient should be able to exhibit normal EOM and normal reaction of pupils to light and accommodation
IV	Trochlear	Downward and inward eye movement	Ask patient to move eyeballs downward and out	Patient should be able to move eyeballs obliquely
V	Trigeminal	Sensation of face, scalp, cornea, and oral and nasal mucous membranes. Chewing movements of the jaw	Elicit blink reflex by lightly touching lateral sclera; to test sensation, wipe a wisp of cotton over patient's forehead for light sensation and use alternating	Patient blinks whenever sclera is lightly touched; able to feel the wisp of cotton over the area touched; able to discriminate blunt and sharp stimuli

			<p>blunt and sharp ends of safety pin to test deep sensation</p> <p>Assess skin sensation as of ophthalmic branch above</p> <p>Ask patient to clench teeth</p>	<p>Patient is able to sense and distinguish different stimuli</p> <p>Patient should be able to clench teeth</p>
VI	Abducens	Lateral eye movement	Ask patient to move eyeball laterally	Patient should be able to move eyeballs laterally
VII	Facial	Taste on anterior 2/3 of the tongue Facial movement, eye closure, labial speech	Ask patient to do different facial expressions such as smiling, frowning and raising of eyebrows; ask patient to identify various tastes placed on the tip and sides of the mouth: sugar, salt and coffee	Patient should be able to do different facial expressions such as smiling, frowning and raising of eyebrows; able to identify different tastes such as sweet, salty and bitter taste
VIII	Acoustic	Hearing and balance	Assess patient's ability to hear loud and soft spoken words; do the watch tick test	Patient should be able to hear loud and soft spoken words; able to hear ticking of watch on both ears

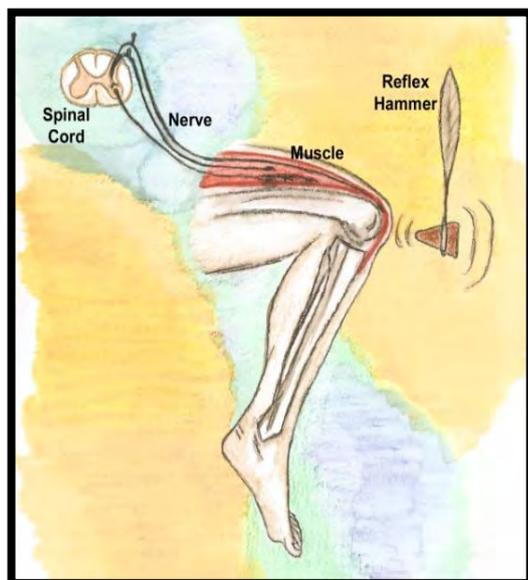
IX	Glossopharyngeal	Taste on posterior 1/3 of tongue, pharyngeal gag reflex, sensation from the eardrum and ear canal. Swallowing and phonation muscles of the pharynx	Apply taste on posterior tongue for identification (sugar, salt and coffee); ask client to move tongue from side to side and up and down; ask client to swallow and elicit gag reflex through sticking a clean tongue depressor into patient's mouth	Patient should be able to identify different tastes such as sweet, salty and bitter taste; able to move tongue from side to side and up and down; able to swallow without difficulty, with (+) gag reflex
X	Vagus	Sensation from pharynx, viscera, carotid body and carotid sinus	Ask patient to swallow; assess client's speech for hoarseness	Patient should be able to swallow without difficulty; has absence of hoarseness in speech
XI	Spinal accessory	Trapezius and sternocleidomastoid muscle movement	Ask patient to shrug shoulders and turn head from side to side against resistance from nurse's hands	Patient should be able to shrug shoulders and turn head from side to side against resistance from nurse's hands
XII	Hypoglossal	Tongue movement for speech, sound articulation and swallowing	Ask patient to protrude tongue at midline, then move it side to side	Patient should be able to protrude tongue at midline and move it side to side

Reflex Assessment

(Adapted: Critical Care Concepts Neuro Assessment Handout; January 4, 2006)

- Upper motor neuron problems (brain and spinal cord) are associated with increased tone. Lower motor neuron problems are associated with decreased tone.
 - Look at the muscles on each side of the body in pairs. Assess for symmetry of bulk.
 - Evaluation of the stretch reflexes assesses the intactness of the spinal reflex arc at various spinal cord levels.
 - The limb should be relaxed while applying a short and snappy blow with a reflex hammer. Hold the hammer loosely in a relaxed manner, making a wrist action. Allow the hammer to bounce.
- Reflex responses:
 - 0: no response
 - 1+ diminished, low normal
 - 2+ average, normal
 - 3+ brisker than normal
 - 4+ very brisk, hyperactive
- Biceps Reflex (C5 – C6):
 - Support the forearm on the examiners forearm.
 - Place your thumb on the bicep tendon (located in the front of the bend of the elbow; midline to the anticubital fossa).
 - Tap on your thumb to stimulate a response.
- Triceps Reflex (C7-C8):
 - Have the individual bend their elbow while pointing their arm downward at 90 degrees.
 - Support the upper arm so that the arm hangs loosely and “goes dead”.
 - Tap on the triceps tendon located just above the elbow bend (funny bone).
- Brachioradialis Reflex (C5-C6):
 - Hold the person's thumb so that the forearm relaxes.
 - Strike the forearm about 2-3 cm above the radial styloid process (located along the thumb side of the wrist, about 2-3 cm above the round bone at the bend of the wrist).
 - Normally, the forearm will flex and supinate.

- Quadriceps Reflex (Knee jerk) L2 – L4
 - Allow the lower legs to dangle freely. Place one hand on the quadriceps.
 - Strike just below the knee cap.
 - The lower leg normally will extend and the quadriceps will contract.



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- If the patient is supine: Stand on one side of the bed. Place the examiners forearm under the thigh closest to the examiner, lifting the leg up. Reach under the thigh and place the hand on the thigh of the opposite leg, just above the knee cap. Tap the knee closest to the examiner, (the one that has been lifted up with the examiners forearm).
- Achilles Reflex (ankle jerks) L5 – S2:
 - Flex the knee and externally rotate the hip. Dorsiflex the foot and strike the Achilles tendon of the heel.
 - In conscious patients, kneeling on a chair can help to relax the foot.
- Heel Lift
 - While the patient is supine, bend the knee and support the leg under the thigh. Have the leg “go dead”. Briskly jerk the leg to lift the heel of the bed. Normally, the leg will remain relaxed and the heel will slide upward; increased tone will cause the heel and leg to stiffen and lift off the bed.
- Babinski Response:
 - Dorsiflexion of the great toe with fanning of remaining toes is a positive Babinski response.
 - This indicates upper motor neuron disease. It is normal in infants.

Sensory Assessment

(Adapted: Critical Care Concepts Neuro Assessment Handout; January 4, 2006)

When assessing sensory function remember that there are three main pathways for sensation and they should be compared bilaterally:

- pain and temperature sensation
- position sense (proprioception)
- light touch
- Pain
 - Can be assessed using a sterile pin.
- Light touch
 - Can be assessed with a cotton wisp.
- Proprioception,
 - Grasp the patient's index finger from the middle joint and move it side to side and up and down. Have the patient identify the direction of movement. Repeat this using the great toe.
- Sensory Tests:

A number of tests for lesions of the sensory cortex can be done. Examples include:

- Stereognosis: The ability to recognize an object by feel. Place a common object in the person's hand and ask them to identify the object.
- Graphesthesia: "Draw" a number in the palm of the person's hand and ask them to identify the number.
- Two-Point Discrimination: Simultaneously apply two pin pricks to the skin surface. Continually repeat the test while bringing the two pins closer together, until the individual can no longer identify two separate stimuli. The finger tips are the most sensitive location for recognizing two point differences while the upper arms, thighs and back are the least sensitive.
- Extinction: Touch the same spot on both sides of the body at the same time (e.g. the left and right forearms. Ask the individual to describe how many spots are being touched. Normally, both sides are felt; with sensory lesions the individual will sense only one.
- Point Locations: Touch the surface of the skin and remove the stimulus quickly. Ask the individual to touch the spot where the sensation was felt. Sensory lesions can impair accurate identification, even if they retain their sensation of light touch.

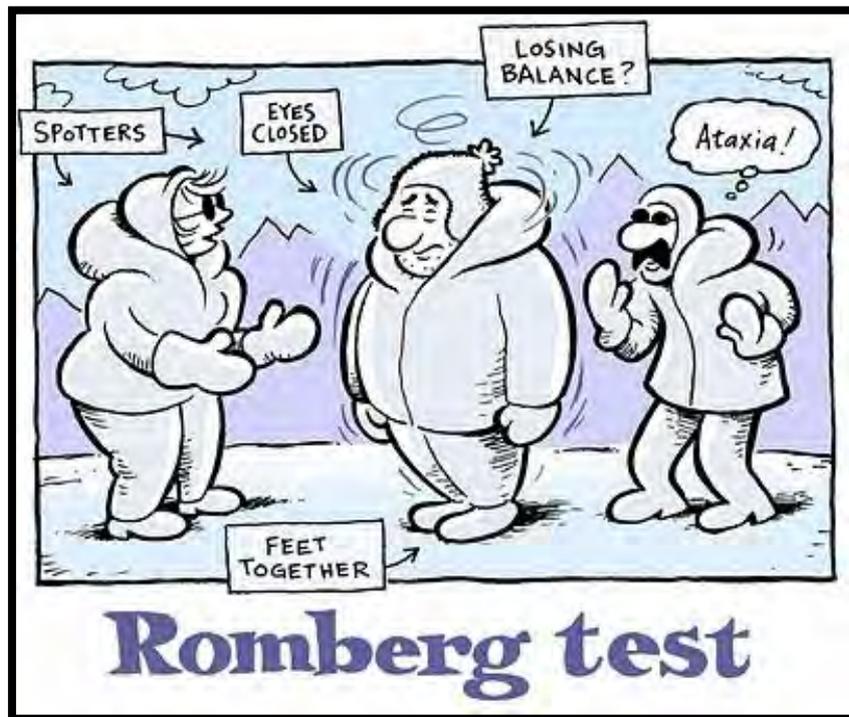
✚ Cerebellum Function Assessment

- The cerebellum is responsible for muscle coordination and balance on the same side.

To test cerebellar functions use the following tests:

- Finger to finger test: have the patient touch their index finger to your index finger (repeat several times).
- Finger to nose test: perform with eyes open and then eyes closed.
- dysdiadochokinesia
- Tandem walking: heel to toe on a straight line
- Romberg test: stand with feet together and arms at their sides.

Have patient close his/her eyes and maintain this position for 10 seconds. If the patient begins to sway, have them open their eyes. If swaying continues, the test is “positive” or suggestive of cerebellum problems.



BRAIN INJURIES

There are many types of brain injuries.

The following will be discussed in this package:

Traumatic Brain Injuries including:

- Extradural/ Epidural haematomas
- Subdural haematomas
- Traumatic subarachnoid haemorrhage
- Intracerebral haemorrhage/contusions
- Diffuse axonal Injury
- Penetrating head injuries
- Approximately 80–85% of strokes are ischaemic; the remainder are haemorrhagic

TRAUMATIC BRAIN INJURIES

Traumatic Brain Injuries (TBI) occurs when an external force injures the brain or spinal cord that is not hereditary, congenital or degenerative.

- **Categories** of TBI

Primary:

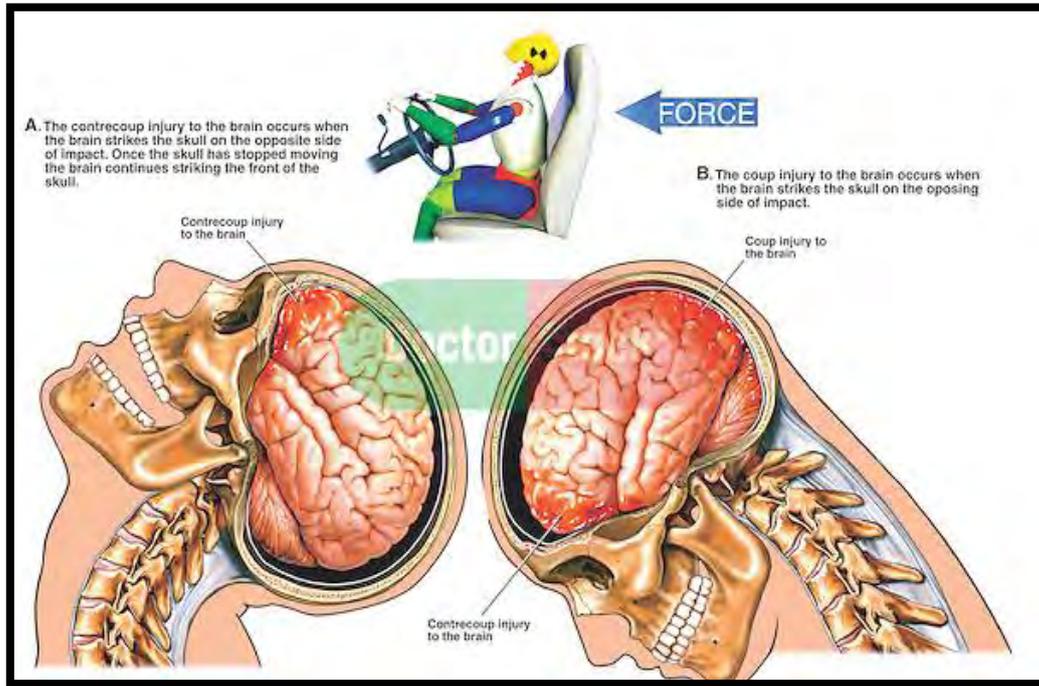
- Damage occurs immediately at time of impact

Secondary:

- Caused by the brain's response to the initial injury & can be changed by medical management

- **Mechanism of Injury**

- **Impact/ contact:** from strike to head or brain hitting inside of skull
- **Acceleration –Deceleration forces:** unrestricted movement of the head that can cause haematoma, vascular & cranial nerve injury
- **Rotational forces:** unrestricted head movement → diffuse axonal injury, axons pulled at microscopic level which disrupt normal neuron function
- **Coup injury** occurs under the site of impact with an object, and a **contrecoup injury** occurs on the side opposite the area that was impacted



Contrecoup injury: doctorstock.photoshelter.com

▪ **Types of TBI's**

✚ **Extradural/ Epidural Haematomas**

- These are usually caused by fracture of the temporal bone and rupture of the middle meningeal artery.
- Following injury blood collects between the skull and the dura.
- Fracture is usually over the middle meningeal artery so the arterial pressure strips the dura away. May also fracture across a dural sinus
- On CT—hyper dense, lenticular, biconvex with sharply defined edges. Limited by dural attachment to skull sutures

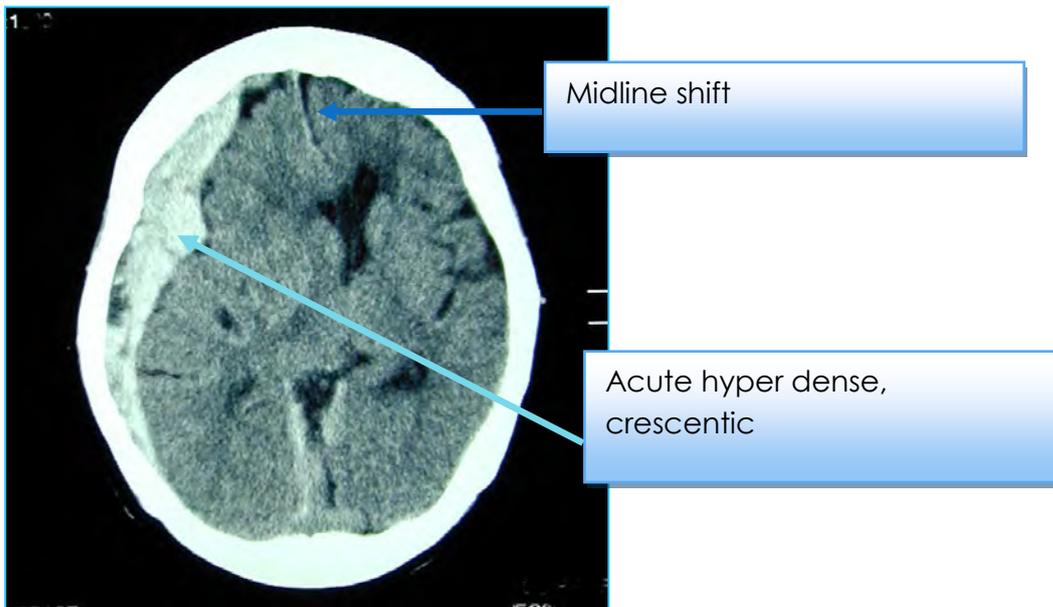


Extradural haematoma:

CEWD Hospital skills programme

✚ Sub-dural Haematomas

- Blood gathers after rupture of the bridging veins between the Dura mater & Arachnoid space
- Acceleration/deceleration injuries when the brain moves relative to the skull
- They can grow large enough to act as mass lesions, and they are associated with high morbidity and mortality rates
- **Acute**-occur within 7 days on CT appear hyper dense and crescentic.



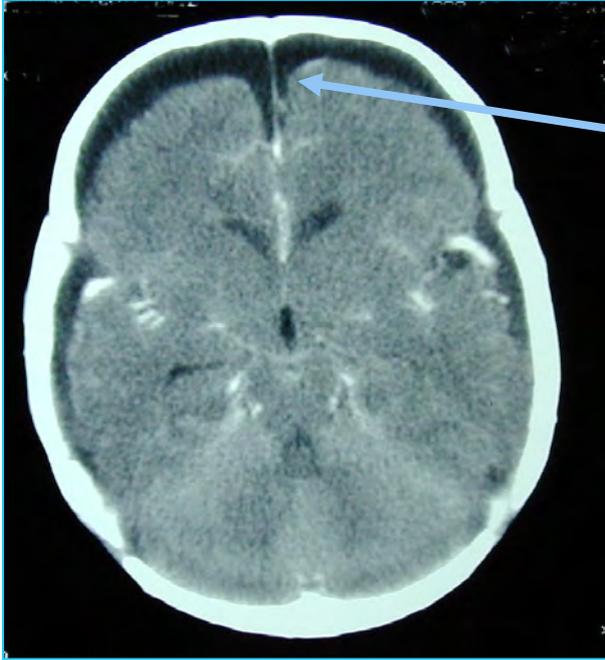
Acute Subdural haematoma: CEWD Hospital skills programme

- **Subacute**-appear from 1 week to 3 weeks. On CT the subdural becomes isodense then hypodense



Sub acute haematoma: CEWD Hospital skills programme

- **Chronic**-appear after 3 weeks. On CT appears isodense



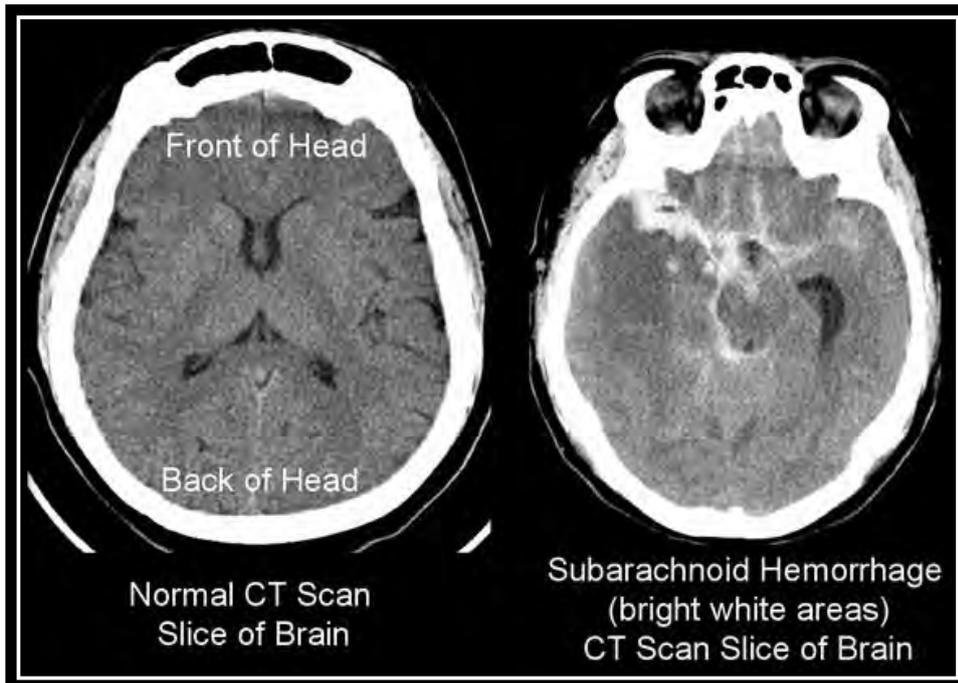
Bilateral crescentic hypo dense

Chronic subdural haematoma: CEWD Hospital skills programme

- **Surgical Management:**⁶
 - Acute subdural hematomas (SDH) >10 mm in thickness or associated with midline shift >5 mm on CT should be surgically evacuated, regardless of the patient's GCS score
 - In addition, surgery is recommended if
 - the GCS score is ≤ 8 or
 - if the GCS score has decreased by ≥ 2 points from the time of injury to hospital admission
 - and/or the patient presents with asymmetric or fixed and dilated pupils
 - And/or intracranial pressure measurements are consistently >20 mmHg.

Traumatic subarachnoid haemorrhage

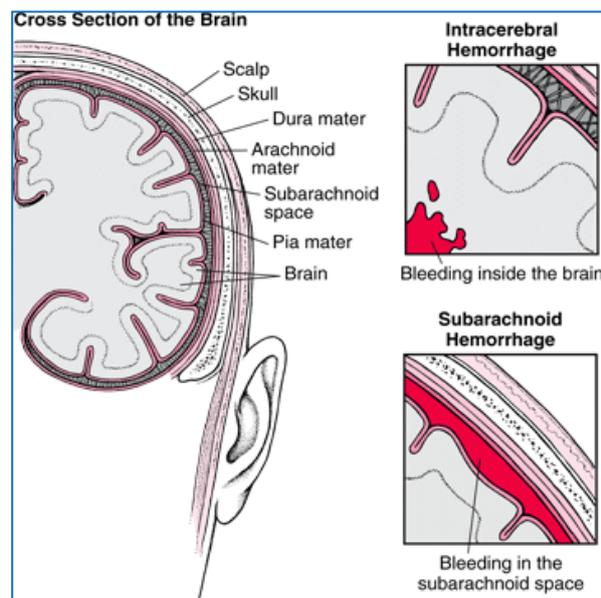
- Bleeding between the arachnoid membrane & pia mater
- Occurs due to the rupture of small veins crossing the subarachnoid space.
- The amount of blood in the subarachnoid space correlates directly with the patient's outcome and inversely to the patients GCS.
- Blood present in CSF
- The subarachnoid blood may stimulate vasospasm or occasionally cause hydrocephalus.



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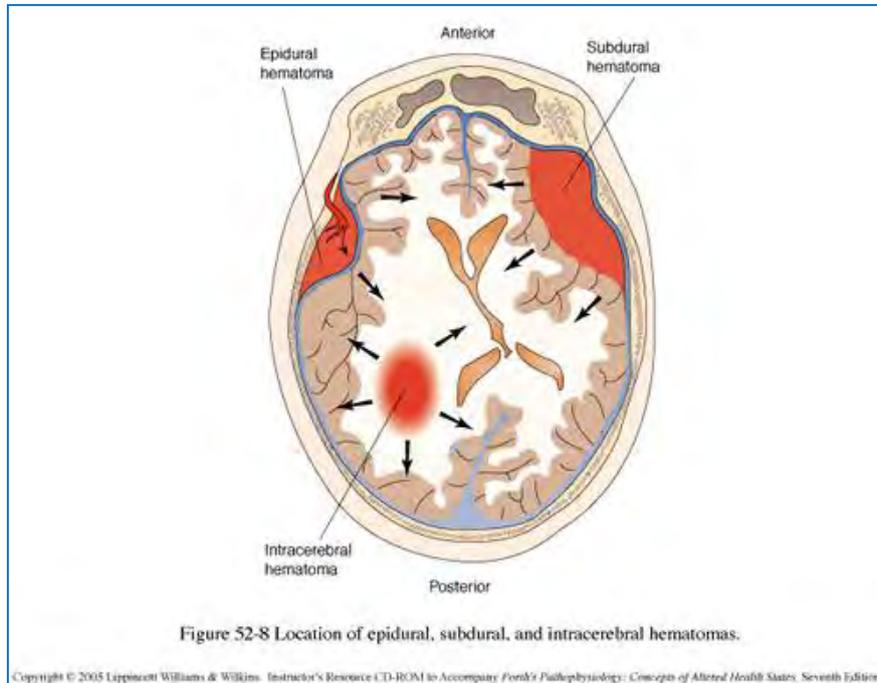
uwmedicine.org

- The appropriate therapy for SAH depends in part on the severity of the bleed. Factors affecting the prognosis are: the level of consciousness on admission, patient age and the amount of blood seen on CT scan ¹⁰



✚ Intracerebral Haematomas

- Bleeding in the brain
- Most commonly hypertensive in origin
- Occurs in brain tissue rather than between brain & skull



- Caused by trauma, CVA (stroke), aneurysms or AV malformations

Surgical Management⁶

- Surgical evacuation of a traumatic intracerebral hemorrhage (ICH) in the posterior fossa is recommended when there is evidence of significant mass effect (distortion, dislocation, obliteration of the fourth ventricle, compression of the basal cisterns, or obstructive hydrocephalus)
- For traumatic ICH involving the cerebral hemispheres, surgical indications are not as clearly defined. Consensus surgical guidelines recommend craniotomy with evacuation if the hemorrhage exceeds 50 cm³ in volume, or if the GCS score is 6 to 8 in a patient with a frontal or temporal hemorrhage greater than 20 cm³ with midline shift of at least 5 mm and/or cisternal compression on CT scan



Un-enhanced axial CT scan of the head.

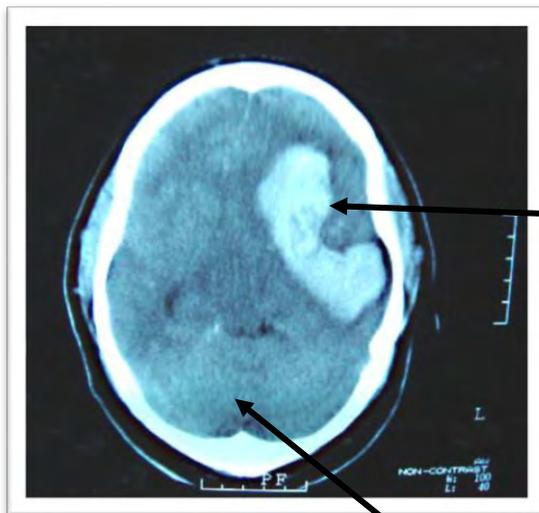
Large acute left basal ganglia and frontal lobe intracerebral hematoma are visible.

There is substantial mass effect obliterating the left lateral ventricle, with left-to-right midline shift and subfalcine herniation (arrowhead).

Intraventricular extension of the haemorrhage (arrow) is also visible.

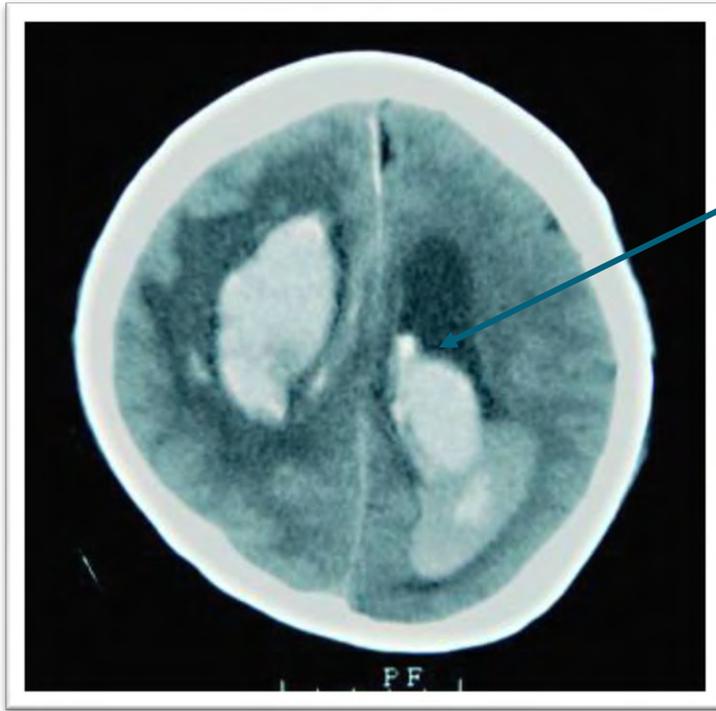
radiology.rsna.org

CEWD. Liverpool Hospital. Hospital skills programme. Dr Alan Gilles



AV malformation
haemorrhage

Poor grey white matter
differentiation
secondary to oedema



Massive intracerebral bleed into ventricles



Multiple intracerebral haemorrhages

✚ Contusions

- Contusions are commonly seen in the basal frontal and temporal areas
- due to direct impact on basal skull surfaces in the setting of acceleration/deceleration injuries

CT scan of the brain depicting cerebral contusions.

The basal frontal areas (as shown) are particularly susceptible.

uptodate.com



✚ Diffuse Axonal Injury

- Shearing mechanisms lead to diffuse axonal injury (DAI)
- Visualized pathologically and on neuro imaging studies as multiple small lesions seen within white matter tracts
- Patients with severe DAI typically present with profound coma without elevated intracranial pressure (ICP), and often have poor outcome.
- This typically involves the gray-white junction in the hemispheres, with more severe injuries affecting the corpus callosum and/or midbrain



CT scan of the brain showing diffuse axonal injury (DAI).

Note the deep shearing-type injury in or near the white matter of the left internal capsule (arrow).

uptodate.com

Penetrating Head Injuries ⁷

Penetrating head injuries are much less common than closed head injuries and they result in death in approximately 50 percent of cases.

Penetrating head injuries primarily result in direct damage to cerebral tissue and haemorrhaging from the penetrating object.

Penetrating head injury can result in very focal impairment (such as in the case of an ice pick or knife blade penetrating the cerebral hemispheres), or relatively diffuse injury from gunshot wound and the secondary shaking, haemorrhaging, and oedema.

Other secondary factors may also complicate this injury.

Surgical Management ⁶

- Superficial debridement and dural closure to prevent CSF leak is generally recommended.
- Small entry wounds can be treated with simple closure.
- Aggressive debridement and removal of deep foreign bodies such as bone or bullet fragments have not been shown to be effective in preventing delayed infection. The use of prophylactic broad-spectrum antibiotics (usually a cephalosporin) is routine in this setting and is believed to have contributed to the reduced incidence of infection in this setting



This patient had normal vision in the right eye (note the knife in the right orbit but had a subtle left sided visual field defect and loss of left visual acuity. Plain films suggested an intra-cranial path. CT scans show the tip of the knife to lie in the area of the optic chiasm.

Abstractsonline.com

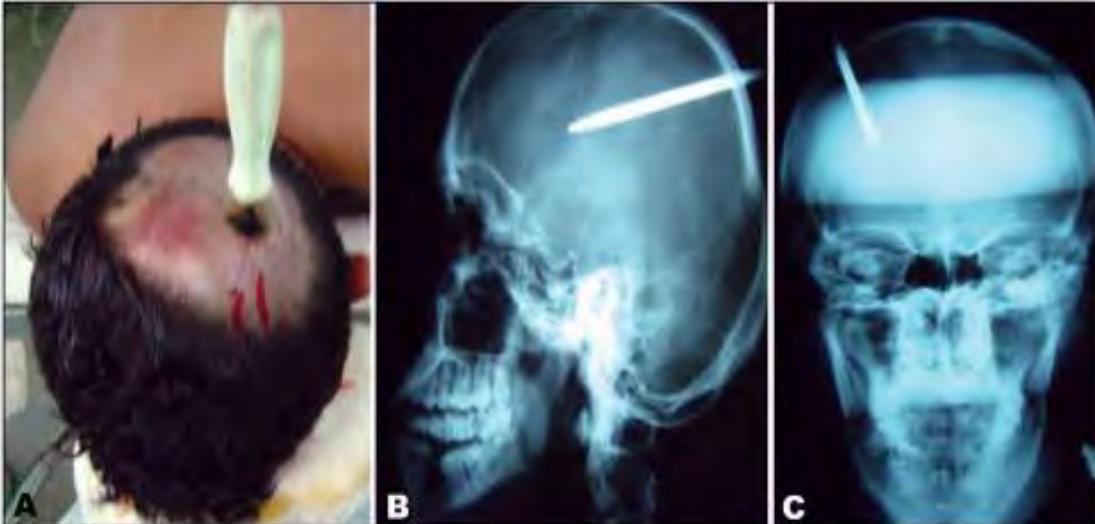


Fig 1A, 1B, 1C. The screwdriver lodged in the left parietal region. Images of plain skull x-rays showing the trajectory of the penetrating agent.

CASE STUDY⁸

A 30-year-old man presented to the emergency department after an assault with a screwdriver sticking out of the head.

He was brought by ambulance and paramedical group. On admission, he was conscious with Glasgow Coma Score (GCS) 15, although he demonstrated disproportioned right hemi paresis and ideational apraxia.

The physical examination revealed the screwdriver lodged in the left parietal region ([Fig 1A](#)).

Axial computerized tomography (CT) scan images showed that the screwdriver had crossed the left hemisphere and reached the frontal region ([Figs 2A, 2B](#)).

The patient was then taken to the operative room in order to remove the foreign body. Under general anaesthesia and on prone position, a small Craniectomy was done surrounding the inflicting object which was pulled out without overdue traction followed by rigorous haemostasis and generous irrigation.

The duramater was sutured in a watertight fashion with prolene 4.0 and a small duroplasty was performed with autologous pericranium.

His neurological impairment recovered completely in two days and he received antibiotics for ten days. He was then discharged without any physical sequelae ([Fig 3A](#)).

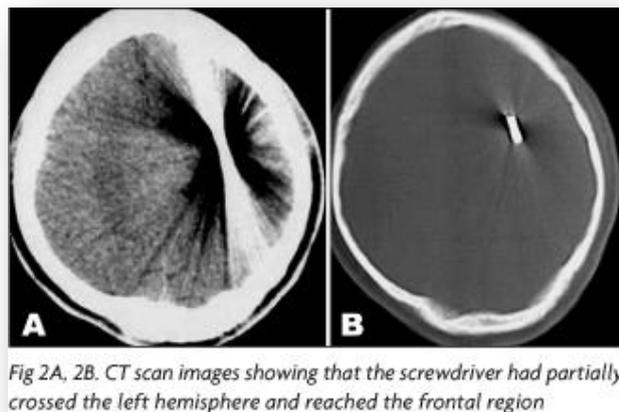


Fig 2A, 2B. CT scan images showing that the screwdriver had partially crossed the left hemisphere and reached the frontal region

On the seventh post-operative day, he had a CT scan done which showed a small hematoma of less than two centimeters in the left middle frontal gyrus, without surrounding edema or signs of mass effect, which was managed conservatively ([Fig 3B](#)).

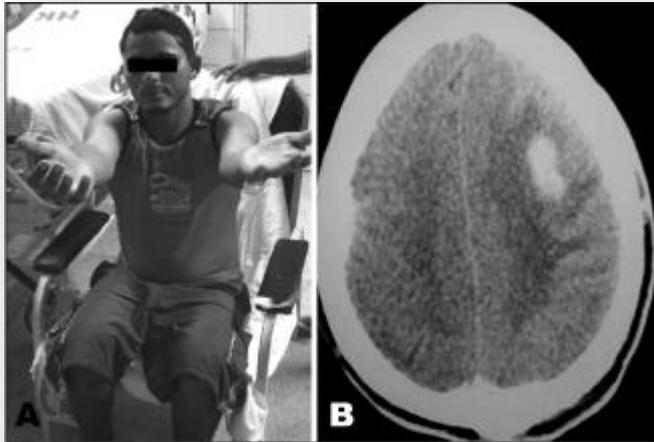


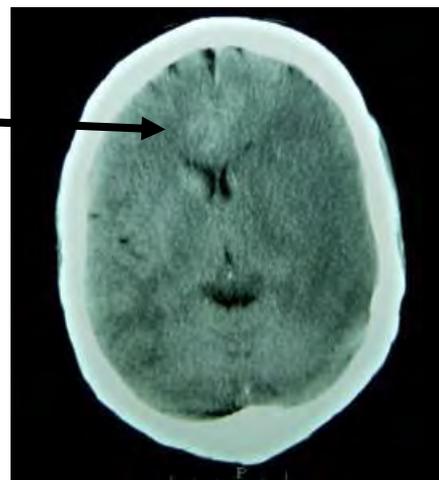
Fig 3A, 3B. Photography to discharge status of patient. Post-operative CT scan image showing a remaining small hematoma in middle frontal gyrus.

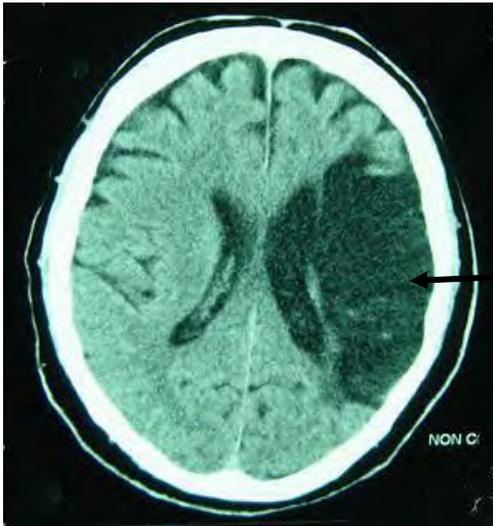
Stroke

Middle Cerebral Artery (MCA)³

- Most common vessel involved for CVA
- In first 24 hrs—effacement of basal ganglia “disappearing basal ganglia sign”, loss of insular cortex, hypodensity of white matter, compression of sulci. May see a high density clot in the MCA.

Over the next days the area will become hypodense





Extensive MCA infarct

Posterior Cerebral Artery³

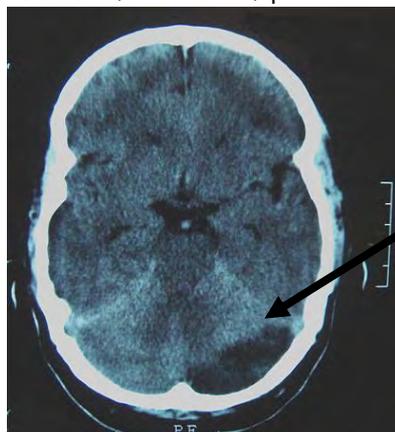
- Affects the medial and posterior temporal lobe and the medial occipital lobe and thalamus on one side

Left occipital (posterior) infarct



Basilar Artery thrombosis³

- May get obstructed by atherosclerosis, embolism, vasculitis.
- May see a bright thrombus in the basilar artery.
- Infarction of the midbrain, thalami, post limbs of the internal capsule may occur.



Left cerebellar infarct

Subarachnoid haemorrhage aneurysmal³

- Most occur in the circle of Willis.
- Most commonly anterior communicating, posterior communicating, bifurcation of middle cerebral, supraclinoid part of ICA.
- May sometimes see a clot and although the haemorrhage is general it is often greater in the region of the rupture.

Blood in sub arachnoid space



Scale for grading severity of SAH¹¹

World Federation of Neurosurgical Societies (WFNS): SAH Grading Scale

GRADE	GCS	CLINICAL SIGNS
I	15	No focal signs
II	13-14	No focal signs
III	13-14	Focal signs present
IV	7-12	+/- focal signs
V	3-6	+/- focal signs

Management of SAH¹²

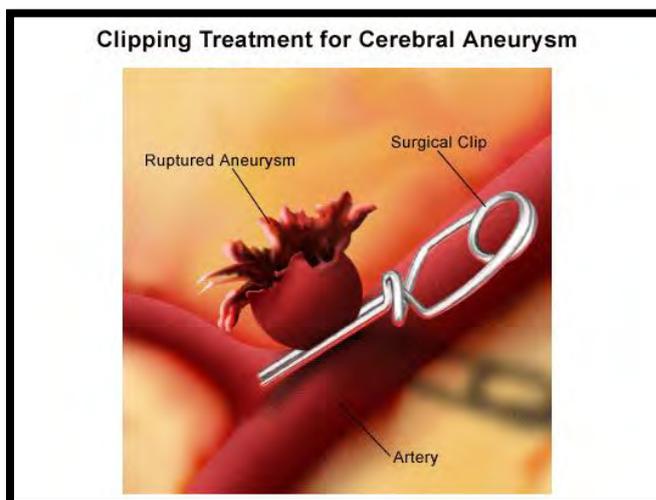
- **ICU Admission**
- Glasgow Coma Score < 15, focal deficit present, WFNS Grade > I.
- Haemodynamically unstable, hypertensive or labile blood pressure.
- Airway compromise, breathing or circulation difficulties.
 - ✓ Intubate
 - ✓ Insert central venous access; avoid internal jugular and femoral veins.
 - ✓ Commence IV nimodipine according to protocol via dedicated lumen.
 - ✓ Consider 40mg simvastatin orally daily, as per Neurosurgeon request.

Criteria for Surgical or Neurointerventional Radiology Management of SAH

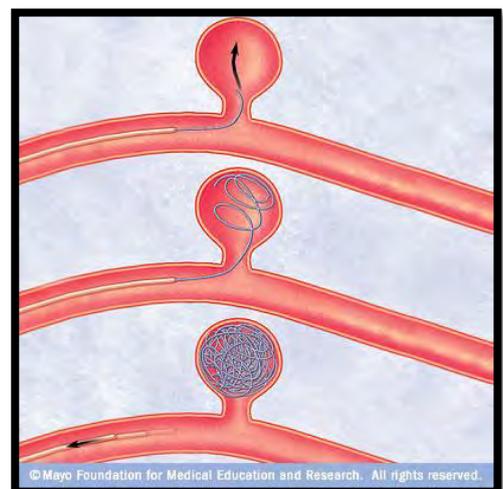
- WFNS I - V and age < 75.
- Good quality of life pre-haemorrhage usually indicates surgical/coiling intervention.
- Poor GCS (in the absence of hydrocephalus or an operable ICH), WFNS Grade V and age > 75 will usually have non-surgical/conservative management:
- If clipping/coiling of aneurysm is unlikely, angiography is not indicated.

ICU admission post coiling / clipping of aneurysm

- On admission to ICU
 - ✓ Receive verbal handover from escort RN and the anaesthetist (if intubated)
 - ✓ Check airway, breathing, circulation and neurological status
 - ✓ Establish continuous haemodynamic monitoring, document Vitals, GCS, pupils, limb strength, EVD observations, ICP and CPP (if available); hourly or more frequently as requested or if clinical state deteriorates.
 - ✓ Check venous and arterial access and infusions, obtain ABG and blood specimens.

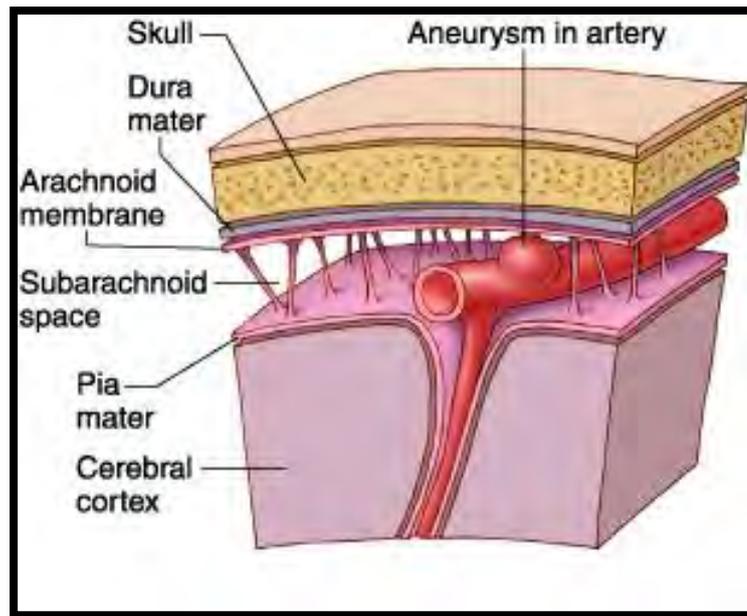


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Ongoing management

- Maintain SBP at prescribed limits, post clipping/coiling hypertension may be used to improve cerebral blood flow.
- Patients with vasospasm may require a higher SBP: usually SBP at 180mmHg, MAP > 90mmHg; noradrenaline may be required as inotropic support.
- ICP < 20-25mmHg, record sudden spikes, report and act upon sustained increases (> 3-5minutes).
- Drain CSF as directed.
- CPP at 60-70mmHg and obtain consult/plan of action if unable to achieve.
- Maintain normo-thermia
- Assess GCS, pupils, limb strength, focal deficit, cranial nerve dysfunction; evidence of clinical vasospasm.
- Vasospasm generally presents from Day 4-10, peak incidence at Day 7 after the initial bleed.
- EVD set at prescribed height above the tragus, 3rd daily CSF specimen
- Nimodipine 10mg in 50mL 0.9% NaCl, via CVC - dedicated lumen at 10mL/hour (30micrograms/kg/hour) or oral 60mg every 4 hours

Nursing care

- Maintain neutral alignment, avoid hip flexion, neck rotation and position patient at least 30 degrees head up in bed.
- Ensure tracheal tapes are not too tight to avoid venous flow obstruction.
- When there is raised ICP, reduce environmental stimulus, family visiting with quiet environment maintained.

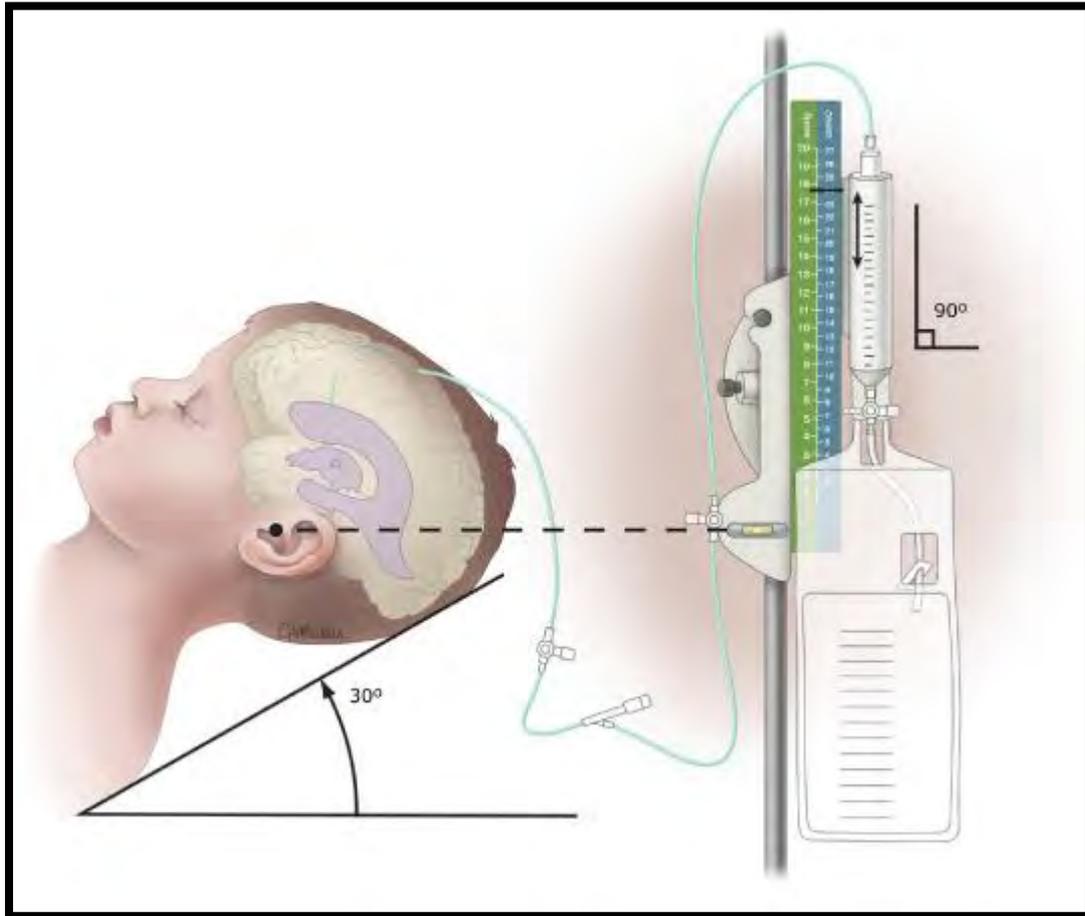
- Ensure rest periods between nursing, medical and allied health interventions.
- Observe for signs of posturing, foot drop, hand/wrist rotation and involve Allied Health staff for appropriate positioning/splinting.
- Once ICP, haemodynamics stable and tolerable headache: patients are encouraged to sit out of bed/mobilise.
- Pressure area care 2nd - 4th hourly and individualised to the patient with raised ICP to maintain skin integrity and CPP.
- Hygiene: eye and mouth care 2nd hourly, daily wash.

Wound care

- Observe surgical site dressing - keep intact, change if ooze noted, take swab for M, C&S. Report and document findings and plan of care.
- Wound may be exposed 48-72 hours post surgery; shower/hair wash after this is allowed.
- Clips/sutures out 5-7days if union attained or as documented

ICP and EVD Monitoring

External ventricular drains (EVDs) are inserted to relieve pressure from within the cranial vault by releasing cerebro-spinal fluid (CSF).



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Increased intracranial pressure (ICP) may occur after an

- Increase in volume of one of the three contents of the cranial vault: tissue, blood or CSF.

Reasons for insertion of an EVD to drain CSF and/or to monitor the ICP are

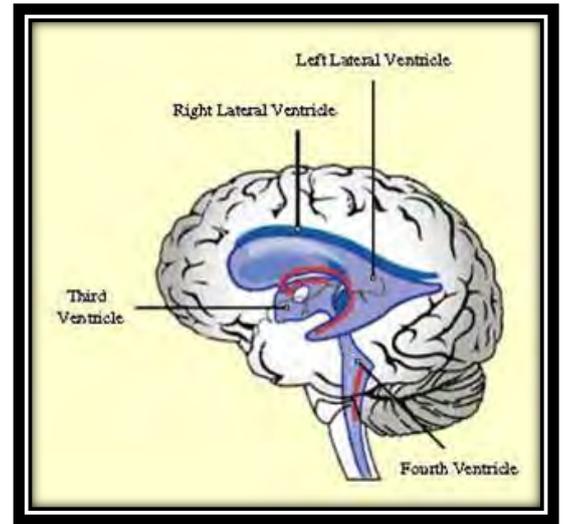
- Haemorrhage,
- cerebral oedema from trauma, tumour or hypoxia, or
- non-communicating (obstructive) hydrocephalus
- To obtain specimens of CSF for analysis and for the instillation of drugs to treat infections.

Insertion¹²

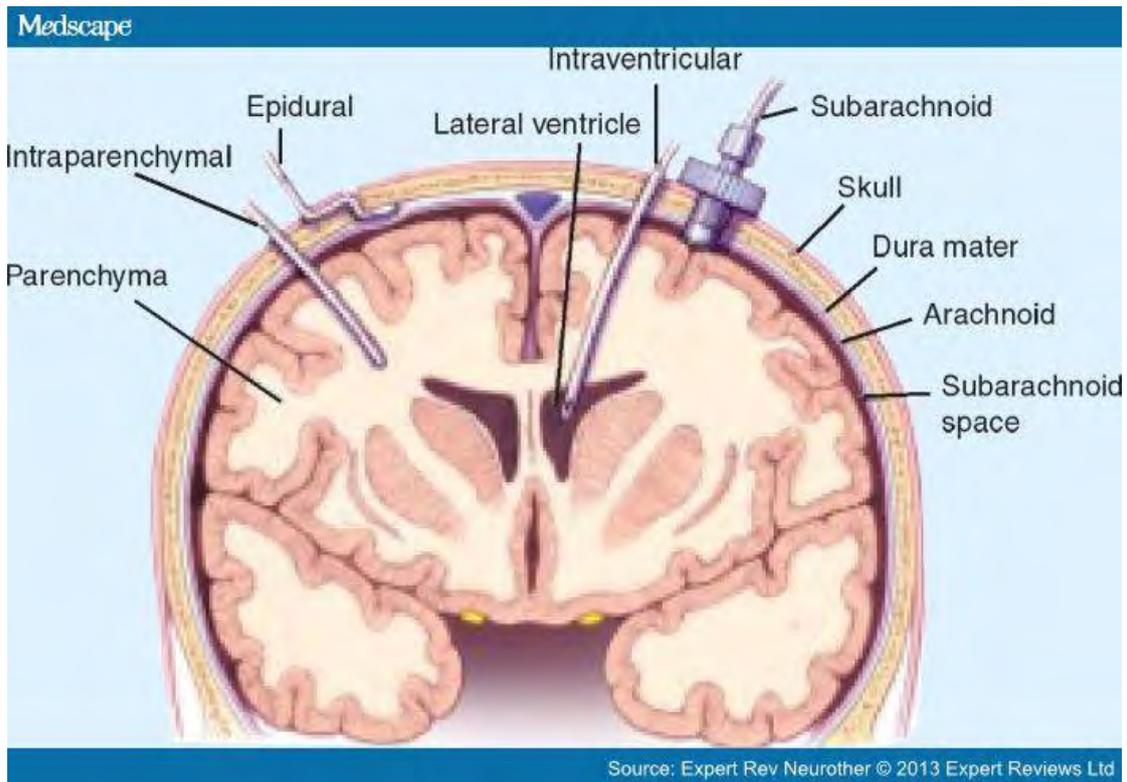
The EVD is placed in the anterior horn of the lateral ventricle of the non-dominant hemisphere (usually the right side)

Types of ICP monitoring devices¹⁴

- Epidural monitor
- Subdural catheter(does not drain CSF)
- Subarachnoid screw or bolt
- Intraventricular catheter (EVD)
- Fiberoptic ICP monitoring device
- Intraventricular
- intraparenchymal ICP microsensor device (does not drain CSF)

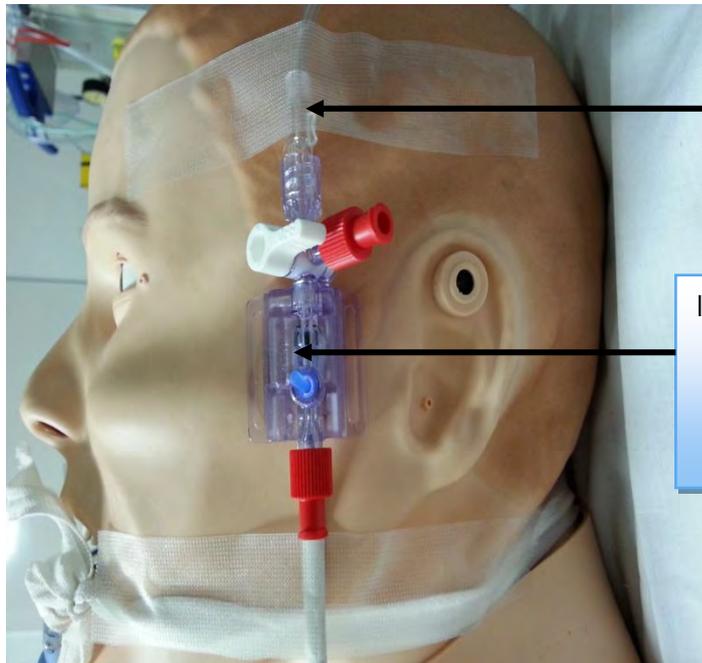


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Positioning of ICP monitoring device and EVD

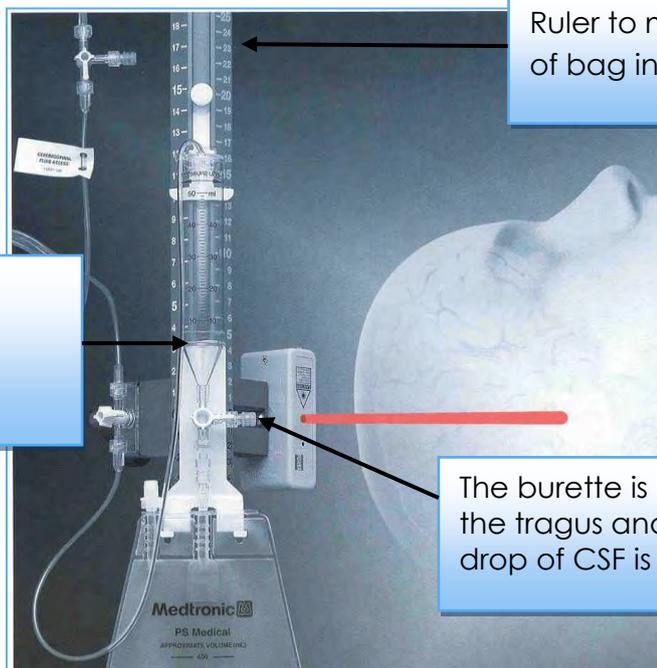
- The Tragus will be the anatomical zero reference point for placement of an external transducer when monitoring ICP.



To EVD

ICP transducer:

- ✓ Level to Tragus.
- ✓ NO pressure bag attached.
- ✓ Red caps only



Ruler to measure height of bag in centimetres

Hourly CSF collection burette

The burette is levelled, using the laser beam, at the tragus and corresponds to where the first drop of CSF is released into the burette.

Securing the EVD¹²:

- The EVD bag must be secured safely to an IV pole to prevent slippage. The IV pole is solely for this purpose.
- An occlusive dressing is applied over the insertion site and re-dressed when soiled or loose.
- Aseptic technique is used when changing the dressing and a swab is taken if there are signs of infection or leakage: report this to the Medical officer

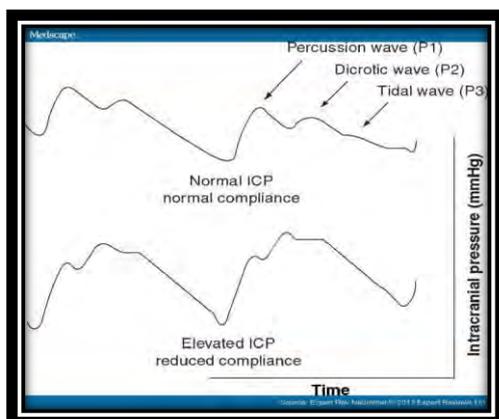
Measuring height in centimetres (cm), relationship to pressure in millimetres (mm) ¹²:

- One mm mercury pressure (mmHg) is equivalent to 1.36cmH₂O height.
- If the EVD is on free drainage at 15cm above the tragus, then the pressure in the brain will need to exceed 11mmHg before CSF will flow out of the brain.
- If the EVD on free drainage is set too high, pressure may increase in the brain with a risk of coning (cerebellar tonsillar herniation) through the foramen Magnum.
- If the EVD on free drainage is set too low or drops suddenly, ventricular collapse may occur with loss of the ability to drain CSF. Alternately, traumatic subarachnoid haemorrhage may occur.

Transport of the patient with an EVD insitu¹²

- The patient is escorted by an accredited registered nurse/ and medical officer if patient ventilated or unstable.
- The EVD is clamped prior to transport and where ICP monitoring is available - monitor ICP during transport.
- The drainage device is to be secured to an IV pole, at the prescribed height above the zero reference point, in case drainage is required during the transport. Ensure the ICP/EVD is free of all other cables/lines.

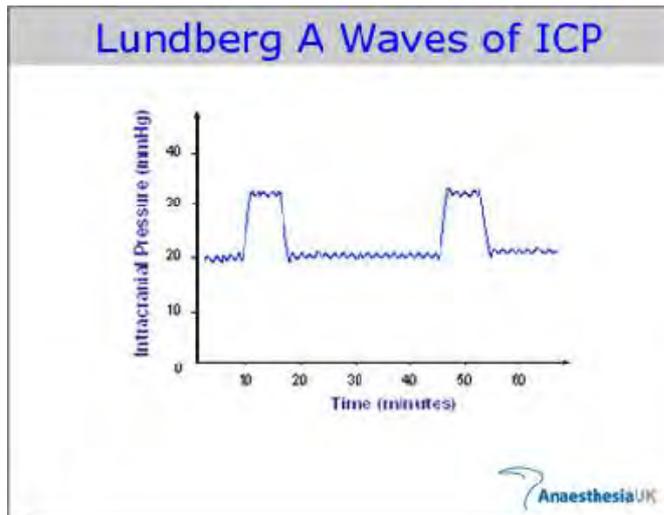
Looking at the monitor if P2 is higher than P1 - it indicates intracranial hypertension.

**ICP waveforms¹³**

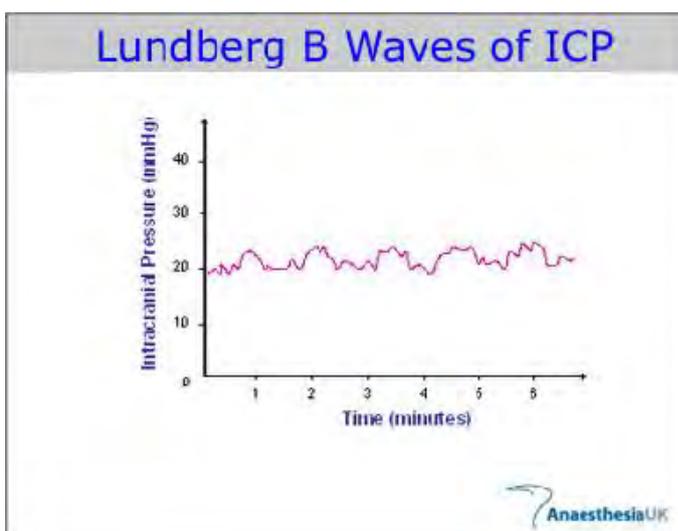
ICP monitoring waveform has a flow of 3 upstrokes in one wave.

- P1 = (Percussion wave) represents arterial pulsation
- P2 = (Tidal wave) represents intracranial compliance
- P3 = (Dicrotic wave) represents aortic valve closure

In normal ICP waveform P1 should have highest upstroke, P2 in between and P3 should show lowest upstroke.



- Lundberg A waves “or plateau waves” are steep increases in ICP lasting for 5 to 10 minutes then drop sharply - signalling exhaustion of the brain's compliance mechanisms. “A” waves may come and go, spiking from temporary rises in thoracic pressure or from any condition that increases ICP beyond the brain's compliance limits.
- They are always pathological and represent reduced intracranial hypertension indicative of early brain herniation.
- Lundberg B waves are oscillations of ICP at a frequency of 0.5 to 2 waves/min and are associated with an unstable ICP. Lundberg B waves are possibly the result of cerebral vasospasm, because during the occurrence of these waves, increased velocity in the middle cerebral artery can be demonstrated on transcranial Doppler.



- Lundberg C waves are oscillations with a frequency of 4-8 waves/min. They have been documented in healthy subjects and are probably caused by interaction between the cardiac and respiratory cycles.

Management of Patient with ICP monitor/EVD¹²

Patient Position:

- The patient should maintain a position of neutral alignment avoiding neck twisting or hip flexion, which may reduce venous return to the heart and thus cause increased ICP.
- The patients head must be elevated at 15-30 degrees (preferably at 30degrees to prevent aspiration, and optimise ICP).

Care activities:

- Avoid performing multiple tasks/clinical interventions - allow for rest periods between tasks.
- EVD - Free Drainage: prior to activities that increase BP / increase ICP (hygiene needs, physiotherapy, turning, lifting etc); clamp the drain; then release the drain clamps upon completion of the activity.
- Respiratory support - optimize oxygenation, cautious use of PEEP, maintain CO₂ on the low side of normal.
- Ensure that endotracheal and tracheostomy tapes are not obstructing venous drainage.
- Decrease external stimuli from the bedside environment - Avoid bright lights, reduce noise level, maintain calm environment.
- Maintain normothermia, this is because for every 1° rise in temperature there is a 10-13% increase in cerebral metabolic rate which leads to an ↑O₂ consumption & ↑CO₂ production, thereby causing ↑ICP & ↓CPP.
- If an EVD is insitu ensure that it is opened, properly levelled and draining CSF.

Managing ICP:

- Optimise required blood pressure (and thus cerebral perfusion pressure) by use of inotropes.
- A CPP of 60mmHg is required to ensure adequate perfusion and oxygenation of the brain.
- Adequate pain relief has been provided and regular pain and sedation assessment/intervention occurs.
- Endotracheal/tracheostomy tapes are firm but not obstructing venous outflow.
- Neuromuscular blocking agents and barbituates may need to be used for control of high ICP not responding to sedation and other interventions.
- Observe the patient for clinical signs of increasing ICP -
 - ✓ nausea,
 - ✓ headache,
 - ✓ decreased level of consciousness,
 - ✓ focal deficit,

- ✓ pupillary changes;
- ✓ Check clamps are released if EVD on free drainage.
- ✓ Report immediately and intervene appropriately.
- ✓ If the patient's ICP remains high they may require a repeat CT scan. Intermittent measures to acutely reduce ICP include hyperventilation, administration of osmotic diuretics, sedation boluses and administration of neuromuscular blocking agents.

Vital signs, Neurological assessment:

- Record neurological observations and vital signs (including temperature) hourly to fourth hourly as prescribed, and more regularly if the patient deteriorates.
- Ensure the patient's haemodynamic status is stable. If BP low - assess fluid and inotrope needs. Elevated BP and ICP indicate a need to lower the ICP initially, and then assess the BP/physical response.

CSF:

- Any change in the nature or volume of the CSF drainage must be investigated and reported immediately.
- A decrease in CSF drainage may indicate blockage of the catheter. Assess CSF along the tubing for pulsation.
- If there is no drainage and no pulsation, contact the Intensive Care Registrar and/or Neurosurgical Registrar immediately. An accredited registered nurse may flush a blocked EVD catheter.
- If there is no drainage for two consecutive hours or there is greater than 20mL CSF drainage in an hour, contact the Intensive Care Registrar and Neurosurgical Registrar immediately.
- During clamping of the drain - observe the ICP. If this increases, cease the activity until the ICP returns to a similar level prior to the activity. If the increase in ICP is sustained despite cessation of the activity and release of the clamps; re-assess patient position, pain and sedation levels, haemodynamics and other causes of increased ICP. Report raised, sustained ICP to the senior medical officer for further management/intervention strategies.
- A CSF specimen is taken 3rd daily for microscopy, culture, sensitivity and evaluation of red blood cells, glucose and protein.

Documentation and intervention:

- Document in the Management Plan area of the ICU flowchart, the set parameters/goals for: MAP, ICP, CPP and the prescription for the EVD: e.g. Hang the EVD at 20cm, drain ICP at 20mmHg.
- Record the drainage of CSF in the burette each hour on the fluid balance section of the flowchart/CIS.
- Empty hourly CSF from the burette into the large collection bag each hour.
- EVD system integrity, including CSF pulsation if drainage is limited
- Levelling of the drainage system at the prescribed height and after patient position change
- Documentation of the volume of drainage (per hour and cumulative), and the consistency and colour of drainage,
- EVD Status:
 - ✓ whether the drain is on free drainage
 - ✓ or set at a specified height to be drained when a prescribed ICP level is breached
 - ✓ When the drain has had to be opened to allow intermittent drainage of CSF
- Where ICP is monitored, record values for MAP and CPP
- Maintain CPP at 60mmHg unless otherwise prescribed by the Intensive Care Senior Registrar or Neurosurgeon/Neurosurgical Registrar.
- Document when a CSF specimen has been taken, when an EVD bag has been changed (change when near full) and record the total volume of CSF discarded.
- Monitor for signs and symptoms of local wound infection, CSF leak or meningitis.

Change of EVD collection bag and replacement

- Inform and explain procedure to patient.
- Double drape a clean dressing trolley, open sterile equipment onto sterile field: sterile fenestrated drape, dressing pack with plastic field, chlorhexidine 0.5% in alcohol 70% and sterile 0.9% sodium chloride soaked gauze squares (separate), new drainage collection bag.
- Clamp EVD: observe ICP; if patient has a single lumen catheter, turn 3-way tap off to the drain, open to monitoring (open to the transducer), continue if ICP tolerated by the patient.
- Don protective eyewear, perform procedural hand wash with antimicrobial liquid soap for 1 minute, don sterile gown and sterile gloves.
- Place sterile paper field under drainage collection bag.
- Swab area thoroughly where the burette joins the collection bag with chlorhexidine 0.5% in alcohol 70%, allow to dry. Rinse thoroughly with sterile 0.9% sodium chloride.
- Place fenestrated drape over the region,
- Disconnect old collection bag and secure new collection bag.

- Using the laser 'spirit-level', the drain is raised/lowered from the zero reference point to the prescribed height in centimetres.
- Keep clamp secured between the hourly CSF collection burette and the larger reservoir (the 'bag').
- Record total amount of CSF drained from the collection bag.
- Ensure all clamps are secured as appropriate and the EVD is set as per the neurosurgical team's prescription.
- Document change of collection bag in the patient's health care record/flowchart/CIS.

Complications

Infection:

- Maintain strict sterile technique.
- Dressing to remain intact unless adherence compromised.
- 3rd daily CSF specimen, drain to be changed if microbe isolated or increased white cell count.
- Reservoir bag emptied only when $\frac{3}{4}$ full.
- Least interruption to the closed system as possible.

Blockage

- Tube may block with blood after subarachnoid haemorrhage or with exudate from an infection.
- The EVD is may be flushed by accredited staff only. An accredited RN in the ICU may flush a blocked drain after consultation with the Intensive Care and Neurosurgical Registrars.
- Observe for drainage, if none and no pulsation of the CSF, inform Medical Officer urgently.

Collapse of cerebral ventricles

- May occur if the bag is too low or falls below the level of the ventricles.
- Excessive drainage of CSF - ventricles will collapse.
- Over drainage and abrupt drainage may damage arachnoid vessels or tear the brain away from the dura, rupturing blood vessels and causing haemorrhage.

Features:

- ✓ Decreasing level of consciousness (LOC), pupils: dilatation, decreased response to light
- ✓ Headache, vomiting, seizure.
- ✓ Vital signs changes: bradycardia, hypertension/hypotension.

Intervention:

- ✓ Report situation to medical officer urgently or as per MET calling criteria.
- ✓ Reposition bag; the patient may require emergency interventional care.

Raised intracranial pressure

- If the bag is too high, there is an inability to drain against a gradient. The pressure within the brain will increase, leading to increasing intracranial pressure and the potential for herniation.

Features (signs of raised ICP):

- ✓ Decreasing LOC, possible seizure, pupillary signs, and changing vital signs.
- ✓ Headache, nausea and vomiting.

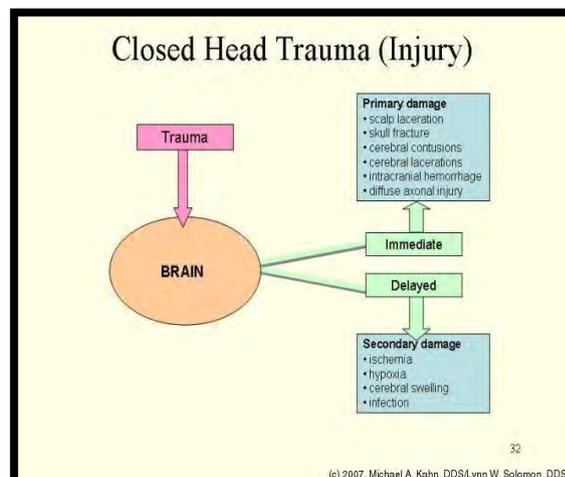
Intervention:

- ✓ Reposition EVD, observe for improvement.
- ✓ Check ICP and BP. If both parameters are high, assess the ICP first and obtain assistance.
- If ICP above prescribed limit, drain CSF.
- Report situation to medical officer urgently
- Patient may require hyperventilation; osmotic diuretics to reverse herniation symptoms and/or a CT scan to rule out other causes.

Management of the Neuro Patient

Secondary Brain Injury

- One insult is superimposed on another as, following the injury, the brain begins to experience reduced blood flow and oxygen deficiency.
- Within minutes or hours after an injury tiny holes rip through neuronal membranes ion channels get stuck open, leaking proteins and neurotransmitters.
- Free radicals and calcium spread, causing cell death and tissue damage.
- Early gene activation of apoptotic enzymes sends more cells into a death spiral.
- Mitochondria sputter, and then fall silent.
- Astrocytes swell.
- The damage can be isolated or extensive.



On arrival to hospital:

- A - Establish airway. Intubate if GCS < 8-9. Ensure C-Spine immobilisation.
- B - Maintain Normocarbida. Do not hyperventilate.
- C - Resuscitate with isotonic crystalloid such as 0.9% sodium chloride (keep Na+ high to minimise cerebral oedema).
- Use Mannitol as a temporary measure to reduce Intracranial HT and hence ICP.

Management

Goals:

- Identify main pathology.
- Treat it.
- Prevent secondary brain injury.
- Process:
 - ✓ Resus of A, B, C.
 - ✓ Identify and treat other co-existing injuries.
 - ✓ Review CT head & spine.
 - ✓ Implement medical and nursing management.
 - ✓ Urgent surgical management

Indications for urgent surgical management

- Acute EDH.
- Acute SDH.
- Acute ICH.
- Cerebral contusion with mass effect.
- Depressed skull fracture, mass effect.
- Insertion of external ventricular drain.
- Need for decompressive Craniectomy

Nursing Management

Maintain: BP, O₂, volume, CPP and ↓ ICP

- ✓ SBP > 90mmHg,
 - ✓ PaO₂ > 90mmHg
 - ✓ CPP > 70mmHg,
 - ✓ ICP < 20-25mmHg
 - ✓ Euvolemia: ?colloids, inotropes
- Adequate levels of sedation & analgesia
- Paralysis for high ICP if indicated
- TOF if patient paralysed (see cisatracurium guideline)
- EEG monitoring if patient having seizures or on thiopentone infusion (see EEG guideline and thiopentone guideline)
- Pathology
- DVT prophylaxis
- Monitor CO₂: 35-38mmHg as it is a vasodilator. 1mmHg increase in PaCO₂ can lead to 4% decrease in CBF
- Normothermic: CBF increases 6% for each degree in temperature increase

- Prevent vasospasm with nimodopine
- Head ↑ 30 deg, neutral alignment. Spinal care (see below)
- Secure ET with anchorfast but not tightly to help with venous return

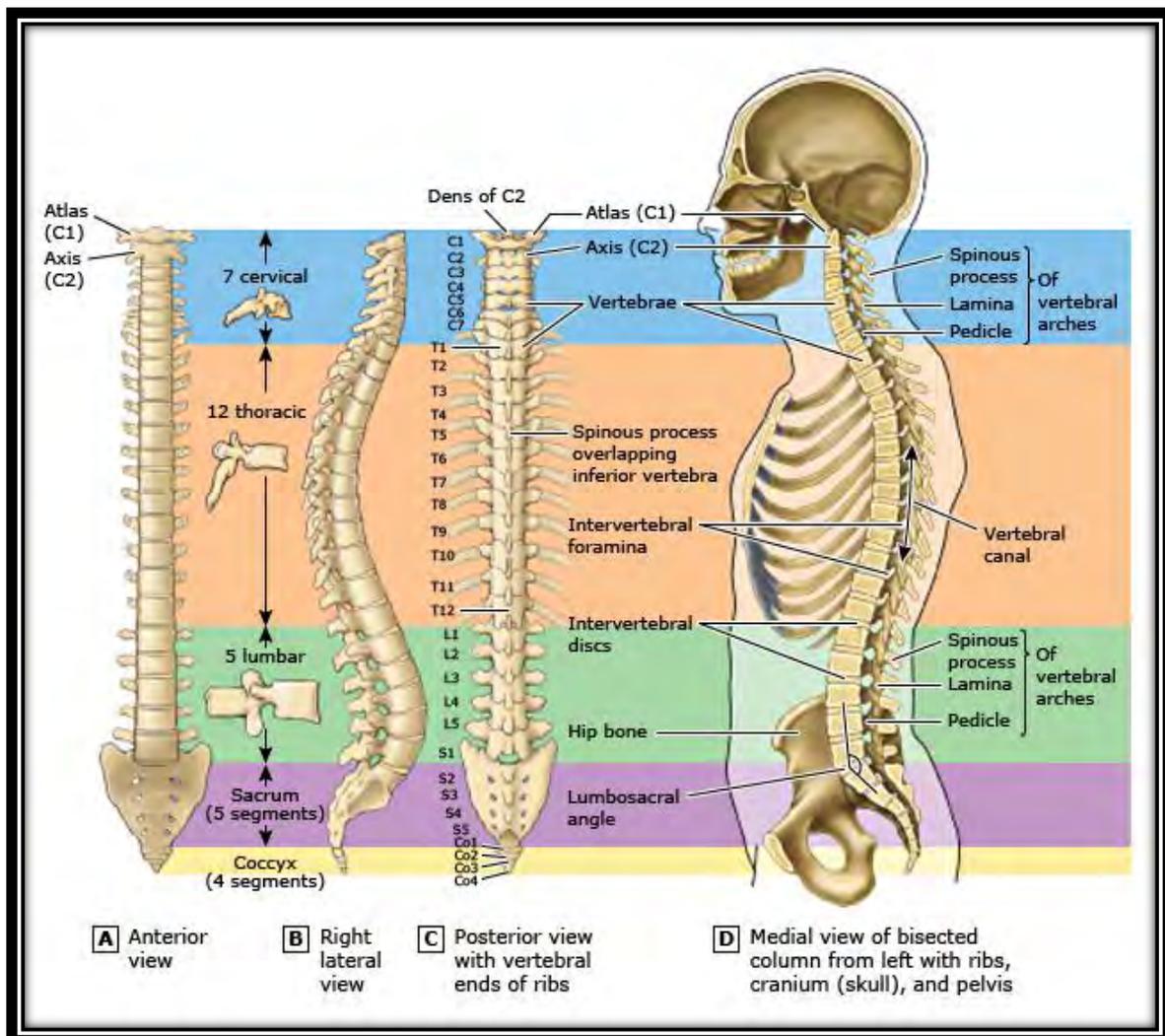
Spinal Injuries¹⁵

Among patients included in a large trauma registry, approximately 3 percent of those with blunt trauma sustain a spinal column injury, such as spinal fracture or dislocation, and 1 percent sustains a spinal cord injury

Motor vehicle related accidents account for almost half of all spinal injuries, and speeding, alcohol intoxication, and failure to use restraints are the major risk factors. Occupants involved in a rollover accident are at increased risk of a cervical spine injury. Other common causes include falls, followed by acts of violence (primarily gunshot wounds), and sporting activities.

Spinal Anatomy

The human spine consists of 33 bony vertebrae: 7 cervical, 12 thoracic, 5 lumbar, 5 sacral (fused), and 4 coccygeal (usually fused)



Classification of spinal injuries¹⁵

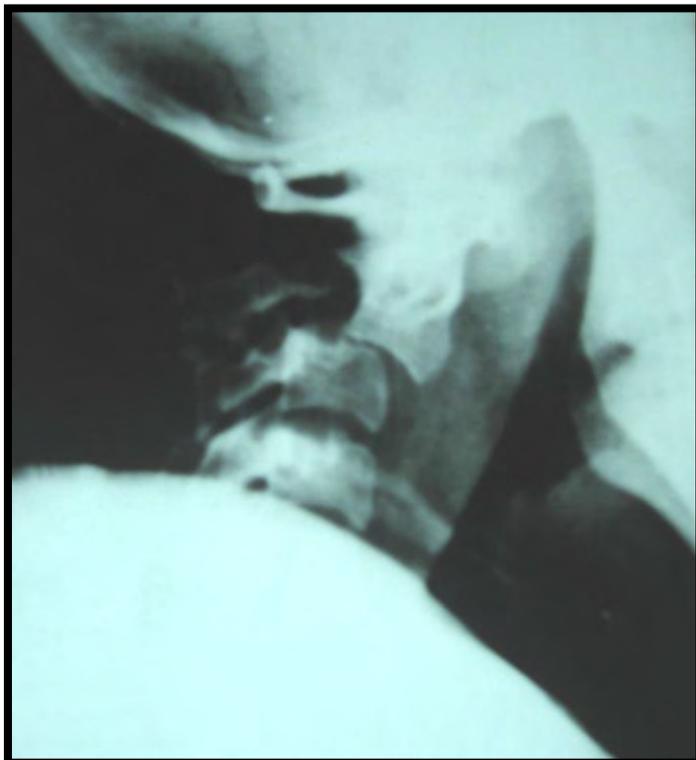
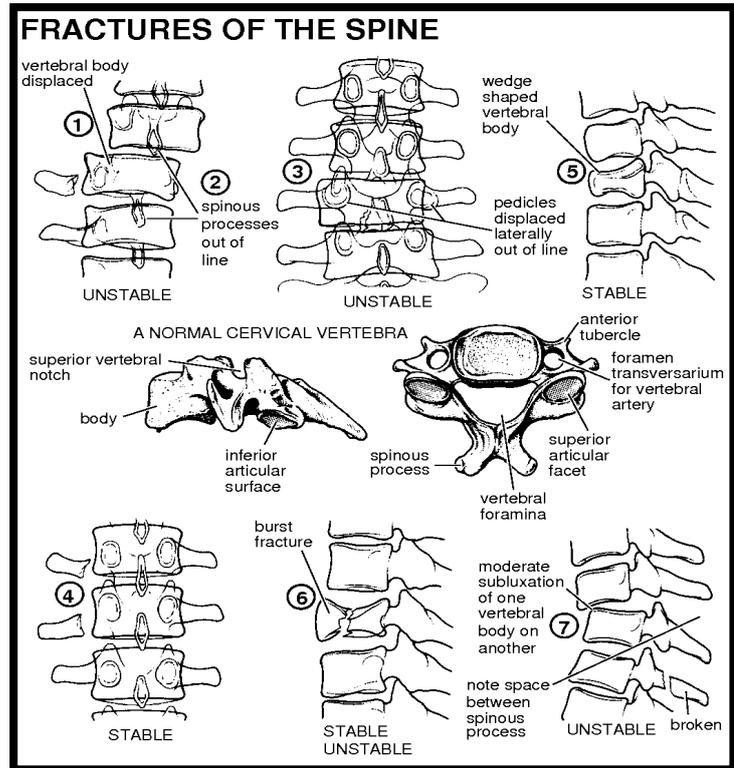
Mechanisms of spinal injury	Stability
Flexion	
Anterior wedge fracture	Stable
Flexion teardrop fracture	Extremely unstable
Clay shoveler's fracture	Stable
Subluxation	Potentially unstable
Bilateral facet dislocation	Always unstable
Atlanto-occipital dislocation	Unstable
Anterior atlantoaxial dislocation with or without fracture	Unstable
Odontoid fracture with lateral displacement	Unstable
Fracture of transverse process	Stable
Flexion-rotation	
Unilateral facet dislocation	Stable
Rotary atlantoaxial dislocation	Unstable
Extension	
Posterior neural arch fracture (C1)	Unstable
Hangman's fracture (C2)	Unstable
Extension teardrop fracture	Usually stable in flexion; unstable in extension
Posterior atlantoaxial dislocation with or without fracture	Unstable
Vertical compression	
Burst fracture of vertebral body	Stable
Jefferson fracture (C1)	Extremely unstable
Isolated fractures of articular pillar and vertebral body	Stable

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Spinal Fractures

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Cervical spine fractures can occur secondary to exaggerated flexion or extension, or because of direct trauma or axial loading

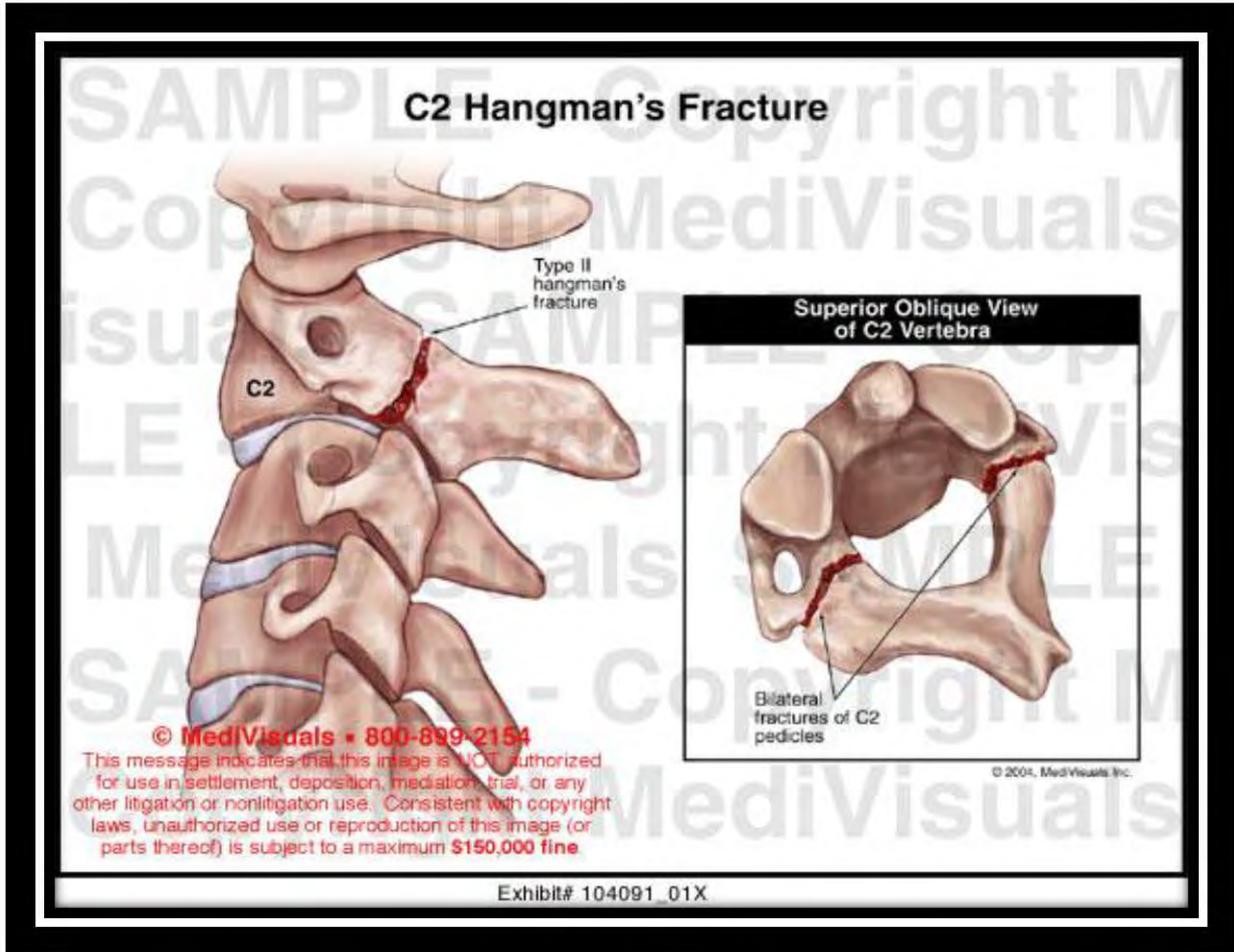


Hangman is a fracture of both *pedicles* or *pars interarticularis* of the axis vertebra (C2) (or, *Epistropheus*).

Lateral c-spine x-ray showing first 4 c-spine vertebrae.

Hangman's fracture

Anterior soft tissue swelling



Dislocation C5 - C6
Quadriplegia

Management of Spinal Injuries¹⁶

First responders should suspect a spinal column injury in

- any trauma victim, especially in the setting of a
- motor vehicle collision
- assault
- fall from a height
- Or sports-related injury

Spinal immobilization, including backboard, rigid cervical collar, and lateral head supports, should be initiated at the scene, and spine immobilization should be maintained until an unstable spinal injury is excluded

Airway management

Airway management problems should be anticipated in patients with cervical spinal column injury.

Unstable lesions above C3 may cause

- immediate respiratory paralysis,

Lower cervical lesions may cause

- Delayed phrenic nerve paralysis from ascending oedema of the spinal cord.

Cervical spinal column injury may be associated with

- Airway obstruction from retropharyngeal haemorrhage, oedema, or maxillofacial trauma.

According to the American College of Surgeons' ATLS® guidelines, endotracheal intubation is the preferred method of airway management for patients with traumatic cardiopulmonary arrest, even with evidence of spinal injury.

Endotracheal intubation in conjunction with rapid sequence intubation is recommended for patients who are breathing but unconscious and in need of airway control or ventilatory support.

In-line spinal stabilization should be maintained throughout the procedure to minimize spinal column movement and reduce the risk of causing or exacerbating a spinal cord injury

Spinal and neurogenic shock — Transient loss of spinal cord function can occur following spinal column injury.

Neurogenic shock from spinal cord injury (usually to the superior portion of the spinal cord) may cause hypotension and bradycardia.

C-Spine imaging

Clinical decision rules for obtaining radiographs¹⁶

Determining which stable, alert trauma patients require imaging of the cervical spine can be difficult.

In an effort to standardize clinical practice and guide physicians to be more selective in their use of radiographs without jeopardizing patient care, two clinical decision rules have been developed.

Both the NEXUS Low-risk Criteria and the Canadian C-spine rule are well validated and sensitive, and either can be used to determine the need for cervical spine imaging.

Examine the patient clinically by following the C Spine Clearance algorithm for conscious trauma patients which utilises the NEXUS / Canadian rules to determine the need for imaging

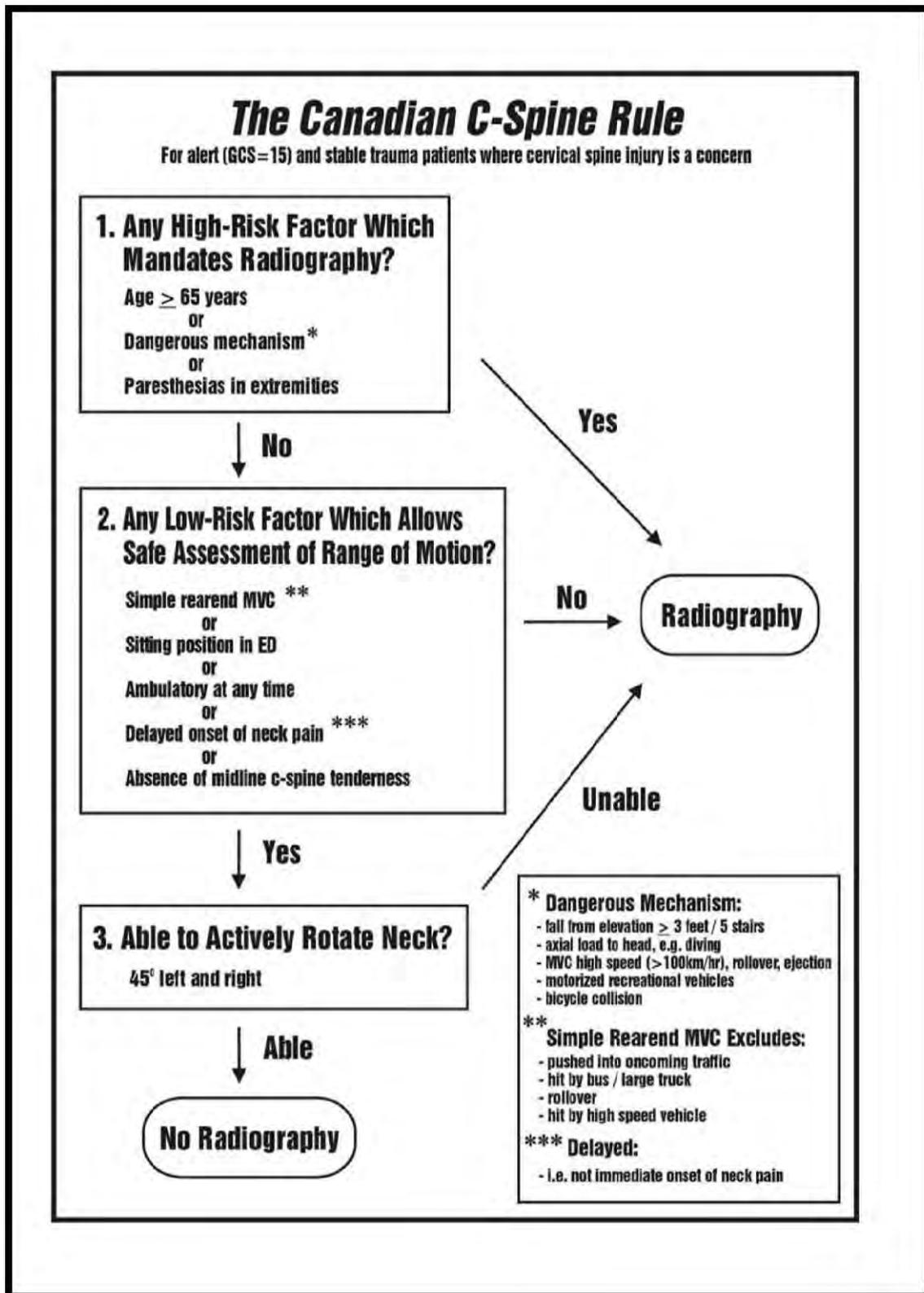


Nexus criteria¹⁷

C-spine imaging is recommended for patients with trauma unless they meet all of the following criteria

- Midline cervical tenderness on palpation?
- Focal neurologic deficit? e.g. paraesthesia, central cord syndrome, radiculopathy
- Intoxication? i.e.. Alcohol, narcotic analgesic, other drugs
- Painful distracting injury e.g. long bone fracture, considerable burns, visceral injury
- Altered mental status i.e. GCS<15

Canadian C-Spine Rule¹⁷



Immobilisation

So that the spinal fracture does not cause a neurological deficit, the patient must be positioned maintaining full vertebral column alignment at all times.

The patient's body must be in a straight line so that when viewed from the head of the bed:

- the tip of the nose is in line with the sternum and symphysis pubis
- iliac crests and shoulders are level
- lower limbs are parallel

When patients are supine avoid hyperextension of the knees;

- keep the feet in line with the hips
- Hold the foot at 90 degrees using foot boards and pillows (unless contraindicated, to avoid pressure on the heels).

The cervical spine must be stabilised with a cervical hard collar appropriately fitted and bilateral head sandbags.

When a patient has a cervical extrication collar (trauma collar) insitu the cervical hard collar (see figure 1) should be removed before 4-6 hours

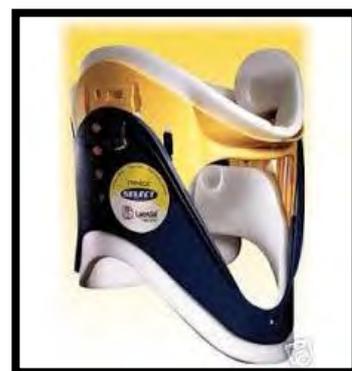


Figure 1



Philadelphia



Aspen

Figure 2

The immobilisation device should be changed to a long term collar e.g. Philadelphia or Aspen collar (see Figure 2)

Philadelphia Collars

How to measure a patient for a Philadelphia collar

- Explain procedure to patient.
- Patient should lie flat with head in neutral alignment.
- Using a tape measure, measure the circumference of the patient's neck in centimetres.
- To give an accurate measurement, the existing collar must be taken off.
- In line stabilisation must be maintained by a second experienced nurse or medical officer when the collar is taken off.
- Using a tape measure, measure from the bottom of the chin to the sternal notch in centimetres.
- Select appropriate collar by applying the patient's measurements to the manufacturers size chart.

Neck Circumference	Measure Chin to Sternum	Collar size
33cm - 38cm	6cm	Medium 2 ¹ / ₄ "
33cm - 38cm	8.5cm	Medium 3 ¹ / ₄ "
33cm - 38cm	11cm	Medium 4 ¹ / ₄ "
33cm - 38cm	13.5cm	Medium 5 ¹ / ₄ "
40.5cm - 45.5cm	8.5cm	Large 3 ¹ / ₄ "
40.5cm - 45.5cm	11cm	Large 4 ¹ / ₄ "
40.5cm - 45.5cm	13.5cm	Large 5 ¹ / ₄ "

Log roll procedure

- Patients must be moved by logrolling with at least four people
- When logrolling the patient, the team leader must hold and support the head, neck and control the turn ensuring that the neck is aligned with the body at all times.
- The team must follow the team leader's directives
- If while being log-rolled or moved, a patient complains of any worsening of pain at the level of injury, pins and needles and/or numbness, weakness, or



any change in neurological signs, the patient must be returned to the supine position

Coordination of a logroll may only be performed by accredited staff

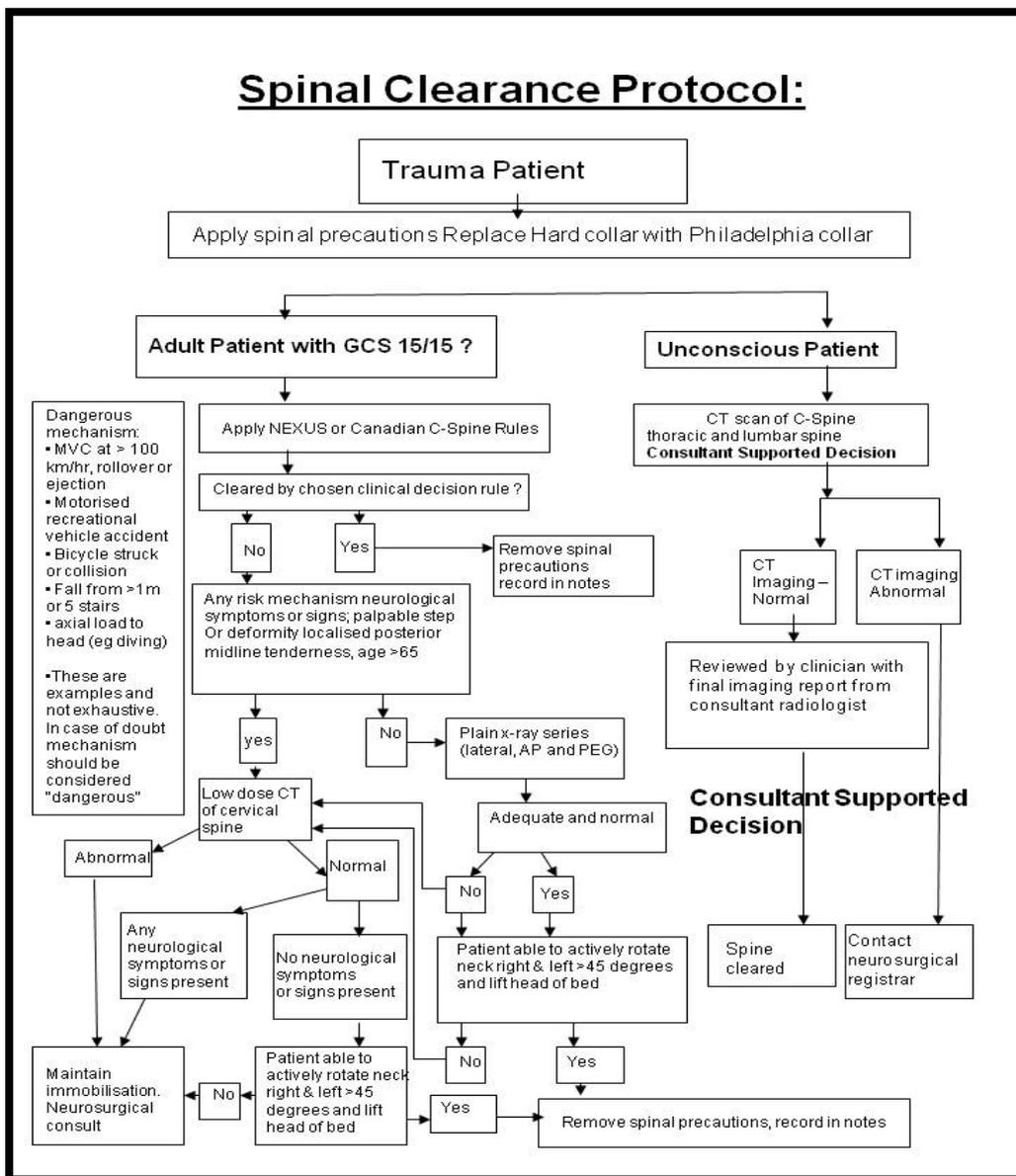
There should be at least 3 assistants rolling the upper body and legs

3 assistants will roll the body and legs a team approach.



- Assistant 1 –near the patient's head and upper body (thorax)
- Assistant 2 – beside Assistant 1, near the patient's hips (pelvis)
- Assistant 3 – beside Assistant 2, near the patient's legs. Responsible for preventing adduction by maintaining the lateral malleolus in line with the hip.

Spinal Clearance¹⁷



- Spinal clearance is said to have occurred when the relevant clinicians have examined the patient physically and radio graphically and have determined that no significant injury exists, at which point, immobilisation procedures are ceased.
- Spinal clearance involves the utilisation of an assessment framework for the evaluation of the spinal status of patients considered to be at risk of spinal trauma.
- The assessment process concludes with either the validation of the lack of injury via the appropriate history, examination and investigation, or the diagnosis and subsequent management of an injury.
- An acute spinal injured patient must not be turned until the Neurosurgeon, Intensivist, Trauma Surgeon or Registrar documents instructions in the patient's health care record
- Documentation includes: (See spinal clearance form)
 - ✓ the injury description
 - ✓ level of injury
 - ✓ management plan
 - ✓ spinal mobility and restrictions

LIVERPOOL HEALTH SERVICE SPINAL CARE FORM			
THIS FORM IS TO BE COMPLETED BY THE ICU CONSULTANT OR SENIOR REGISTRAR		Surname	Given Names
Address - Street		Suburb	Postcode
Date of Birth	Sex	ABO	
Hospital Name		Ward	
Date Spinal Care Form Completed: _____			
CERVICAL SPINE			
CT Scan Attended: Yes <input type="checkbox"/> No <input type="checkbox"/>		Plain Films Attended: Yes <input type="checkbox"/> No <input type="checkbox"/>	
Cleared:	Radiologically	Yes <input type="checkbox"/> No <input type="checkbox"/>	Comments:
	Clinically	Yes <input type="checkbox"/> No <input type="checkbox"/>	
Cleared by:	Designation:	Date:	Neurosurgical Radiologist <input type="checkbox"/>
THORACIC SPINE			
CT Scan attended: Yes <input type="checkbox"/> No <input type="checkbox"/>		Plain Films attended: Yes <input type="checkbox"/> No <input type="checkbox"/>	
Cleared:	Radiologically	Yes <input type="checkbox"/> No <input type="checkbox"/>	Comments:
	Clinically	Yes <input type="checkbox"/> No <input type="checkbox"/>	
Cleared by:	Designation:	Date:	Neurosurgical Radiologist <input type="checkbox"/>
LUMBAR SPINE			
CT Scan Attended: Yes <input type="checkbox"/> No <input type="checkbox"/>		Plain Films Attended: Yes <input type="checkbox"/> No <input type="checkbox"/>	
Cleared:	Radiologically	Yes <input type="checkbox"/> No <input type="checkbox"/>	Comments:
	Clinically	Yes <input type="checkbox"/> No <input type="checkbox"/>	
Cleared by:	Designation:	Date:	Neurosurgical Radiologist <input type="checkbox"/>
PATIENT POSITIONING PLAN			
Jordan frame is permitted:	Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>
Log roll is permitted:	Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>
Cervical collar required:	Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>
Philadelphia collar required:	Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>
Sand bags:	Yes <input type="checkbox"/>	No <input type="checkbox"/>	N/A <input type="checkbox"/>
Position patient:	Supine <input type="checkbox"/>		
	Head of bed can be raised to _____ °C		
	Can sit up without restrictions <input type="checkbox"/>		
SPECIAL INSTRUCTIONS:			
• _____			
• _____			
• _____			
• _____			
• _____			
AUTHORISATION: ICU Consultant / Senior Registrar to complete			
FULL NAME		SIGNATURE	DATE

BINDING MARGIN - NO WRITING
FILE IN CLINICAL RECORD

REORDER PRINT ROOM (PHOTOCOPIES)

ICU SPINAL CARE FORM

CR 124

Management of Spinal Injuries²⁰

▪ **Respiratory Management:**

- Includes intubation and ventilation.
- Chest physiotherapy as they often have poor cough and need assistance with clearing secretions.

▪ **Autonomic Dysreflexia:**

The most hazardous event that affects the spinally injured patient is the development of autonomic dys-reflexia. This involves intense vasoconstriction of the blood vessels in the area supplied by the nerves from the damaged part of the spinal cord. Possible causes are:

- Distended bladder (the most common cause is a blocked urinary catheter)
- Distended bowel (usually caused by constipation)
- Pressure sore
- Urinary tract infection/bladder spasms
- Renal calculi/bladder calculi
- Visceral pain or trauma
- Deep-vein thrombosis/pulmonary embolism
- Severe anxiety/emotional distress

The problem generally manifests itself as acute hypertension and, if left unresolved, can cause fatal cerebral haemorrhage. There may also be bradycardia, as the baroreceptors try to slow the heart rate via the vagus nerve to compensate for the drastic rise in systemic blood pressure.

Treatment is by swift removal of the offending stimuli and, if necessary, administration of an antihypertensive agent to control the blood pressure.

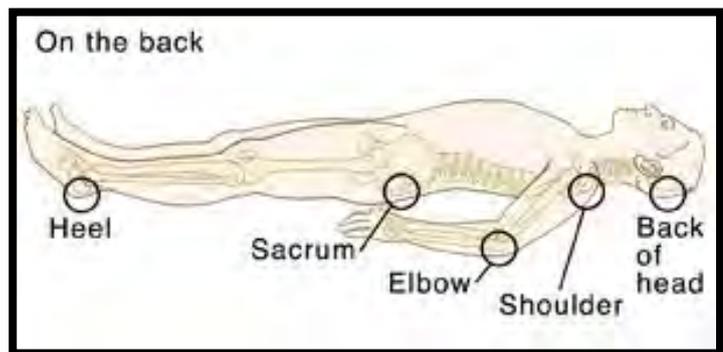
▪ **Spinal Shock:**

In a complete cord transection, the patient immediately goes into the state of "spinal shock". This is a complete loss of cord function below the level of the lesion. This leads to:

- Flaccid paralysis
- Bladder dilatation, retention and overflow incontinence.
- Patulous anus
- Paralytic ileus

There may be a combination of neurogenic and hypovolemic shock. In neurogenic shock, unlike hypovolemic shock, the pulse rate is slow and of good amplitude and the skin is usually warm and dry. Tachycardia and clammy skin are seen in hypovolaemia. Cautious fluid resuscitation should be used in neurogenic shock. Vasoconstrictors and atropine may be used to maintain cardiac output.

- **Gastrointestinal issues:**
 - A nasogastric tube should be inserted to decompress the stomach and prevent its impinging on the diaphragm and worsening respiratory problems.
 - There may also be a paralytic ileus in the early stages. Once this has resolved, it may be necessary to implement enteral feeding via the nasogastric tube:
 - require a high calorific and high-protein intake to combat the negative nitrogen balance associated with immobility.
- **Temperature Control:**
 - These patients are poikilothermic.
 - Their environment must be kept at a constant temperature, otherwise they rapidly become hyperthermic or hypothermic, depending upon the environmental temperature.
- **Elimination:**
 - A urinary catheter should be inserted at the earliest opportunity in spinal-injured patients, as urine retention is likely.
 - Closely monitor urine output and prevent over distension of the bladder.
 - Monitor closely for signs of urinary tract infection.
 - Bowel Management: Location and completeness of cord injury determines the extent of impairment to control defecation. The patient may need regular aperient regime to prevent constipation.
- **Pressure Area Care:**
 - Regular pressure area care is important as these patients are high risk for pressure areas.
 - Log roll, avoid turning onto discoloured areas of skin, and protect heels.
 - Minimise the risks of other contributory factors for pressure sore formation:
 - maintain adequate nutrition/hydration, correct anaemia's
 - clean patient as soon as possible after soiling.
 - Check and observe around and under the hard collar for impending skin breakdown and pressure ulcers.
 - Any cervical collar including Rigid, Philadelphia and Aspen collars can cause pressure ulcers if care is not taken to protect bony prominences.
 - Strict attention to hygiene of the collar and the patient's skin will assist to prevent pressure ulcers and maintain skin integrity.



Neurological Drugs

- Nimodopine
- Mannitol
- Cisatracurium
- Dexmedetomidine
- Thiopentone
- Magnesium
- Phenytoin
- Sodium Valproate
- Propofol
- Midazolam

See attached Pharmacological Guidelines

Appendix

EEG guideline

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