HYDROCEPHALUS

Hydrocephalus is a condition in which there is disequilibrium between CSF production and absorption, leading to:-

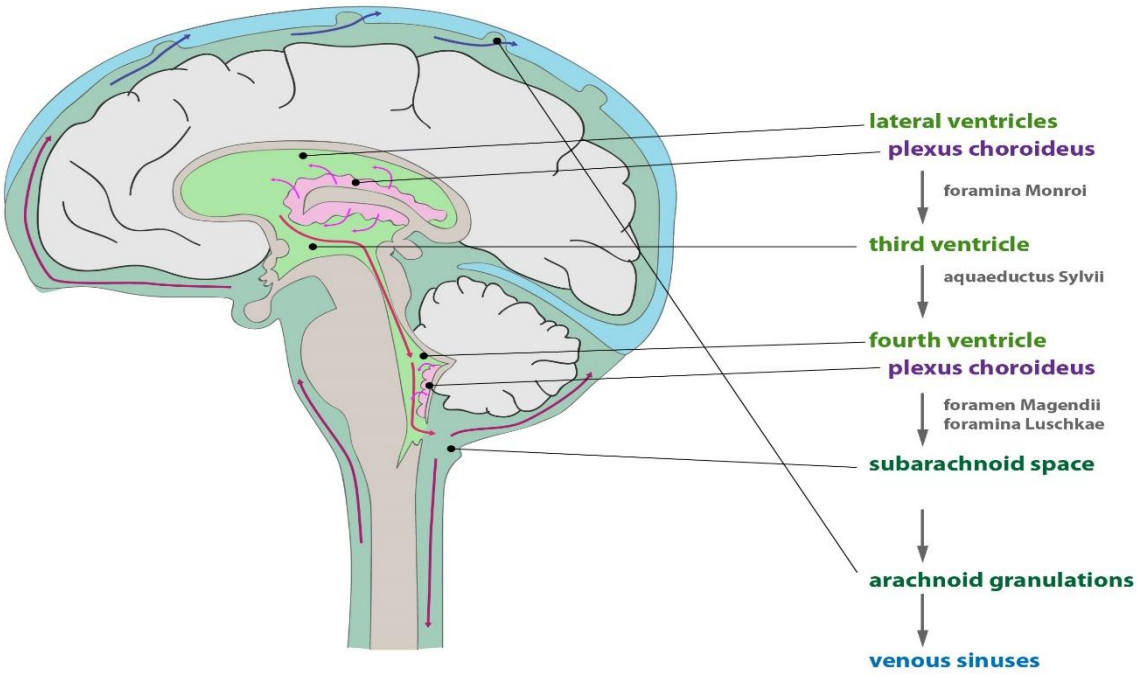
1. Raised ICP, and is
2. Often associated with dilated ventricles.

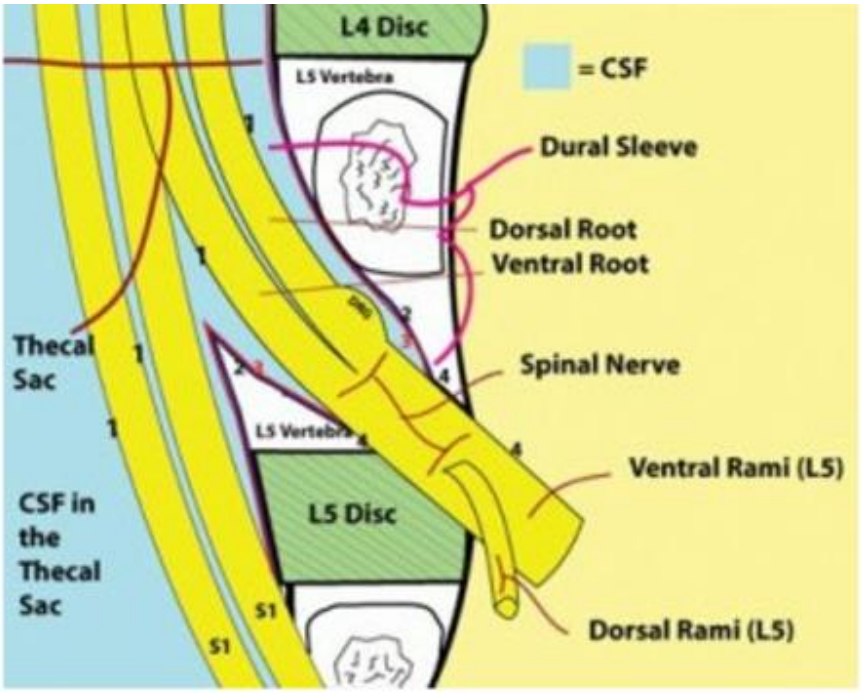
Note:

I. Not all patients with ventriculomegaly have hydrocephalus and;
II. Not all patients with hydrocephalus necessarily have enlarged ventricles.

Cerebrospinal fluid physiology

- The total CSF volume in an adult is about 150 ml and it is distributed between the cerebral ventricles (approximately 35 ml), the cerebral subarachnoid space and the spinal thecal sac.
- The thecal sac or dural sac is the membranous sheath of dura mater that surrounds the spinal cord and the cauda equina. The thecal sac contains the cerebrospinal fluid in which the spinal cord 'floats
- CSF production occurs at a rate of approximately 0.33 ml min–1 or 450 ml day-1, resulting in a turnover of three volumes per day.
- CSF production is primarily by the choroid plexus of the ventricles and is an active process independent of ICP. Some CSF production occurs by transependymal spread through the ventricular walls from the cerebral extracellular fluid, and from the spinal dural nerve root sheaths.
- CSF flows from the lateral ventricles, through the foramen of Munro, into the third ventricle and then into the cerebral aqueduct and fourth ventricle before exiting into the subarachnoid space via the midline foramen of Magendie and lateral foramina of Lushka.
- CSF absorption is a pressure-dependent passive process involving filtration across the arachnoid villi, which are abundant along the superior sagittal sinus into which the CSF is absorbed.
- Relative to plasma, CSF has a lower potassium and calcium content but is richer in chloride and magnesium. Normal protein content is 0.15–0.45 g l–1. CSF is slightly acidic relative to plasma (pH 7.33–7.35).


lateral ventricles
plexus choroideus
foramina Monroi
third ventricle
aquaeductus Sylvii
fourth ventricle
plexus choroideus
foramen Magendii
foramina Luschkae
subarachnoid space
arachnoid granulations
venous sinuses


L4 Disc
= CSF
L5 Vertebra
Dural Sleeve
Dorsal Root
Ventral Root
Thecal Sac
Spinal Nerve
L5 Vertebra
Ventral Rami (L5)
CSF in the Thecal Sac
L5 Disc
S1
Dorsal Rami (L5)
S1

Aetiology of hydrocephalus

Hydrocephalus can be obstructive or communicating. ***Obstructive hydrocephalus*** can be caused by any lesion blocking the CSF pathways from the lateral ventricles to the fourth ventricle. Susceptible sites include the foramen of Munro (colloid cyst of the third ventricle) and cerebral aqueduct (congenital aqueduct stenosis). Lesions may be within the ventricle, in the ventricular wall or distant from the ventricle but exerting mass effect on it.

Posterior fossa mass lesions are more likely to present with obstructive hydrocephalus because the fourth ventricle is easily compressed within the relatively small posterior fossa.

Communicating hydrocephalus refers to circumstances in which the intracerebral CSF pathways are patent but there is accumulation of CSF, usually due to impaired CSF absorption.

This may be because the CSF constituents have altered such as in cases of meningitis or subarachnoid haemorrhage (SAH).

Cerebrospinal fluid physiology

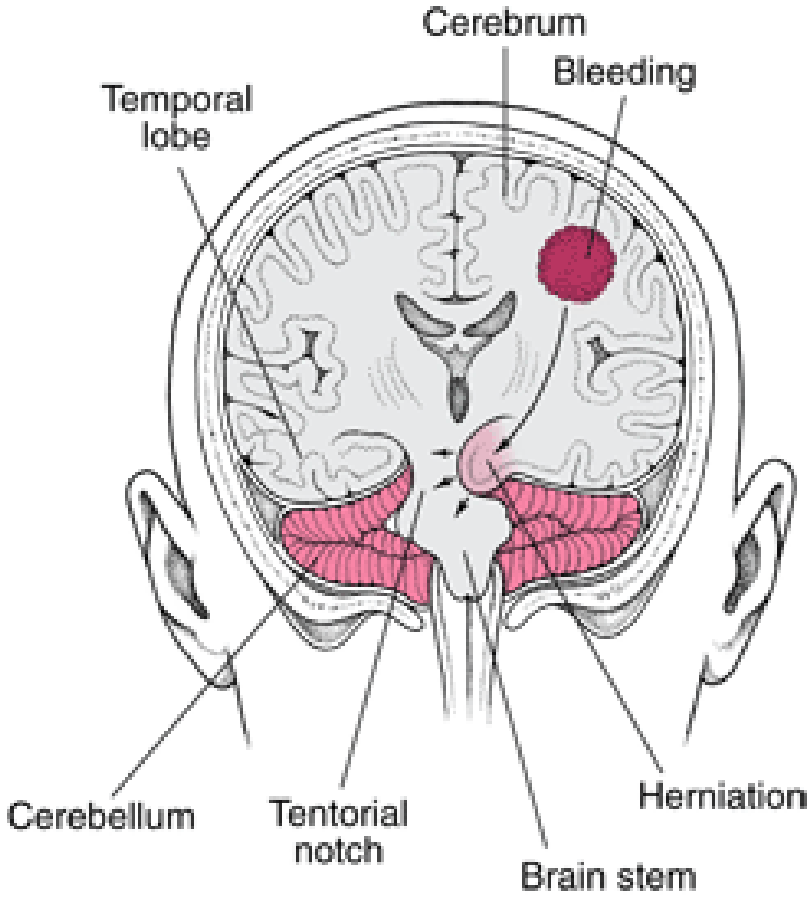
Volume	150 ml
Production	20 ml h–180% by choroid plexus
	Active process
Absorption	At arachnoid villi
	Pressure dependent
Relative to plasma	Reduced K+ and Ca2+
	Increased Cl- and Mg2+
	pH 7.33–7.35

Aetiology of hydrocephalus

Obstructive hydrocephalus	Lesions within the ventricle
	Lesions in the ventricular wall
	Lesions distant from the ventricle but with a mass effect
Communicating hydrocephalus	Post haemorrhagic
	CSF infection
	Raised CSF protein
Excessive CSF production (rare)	Choroid plexus (papilloma/carcinoma)

Investigation

Lumbar puncture is contraindicated in *obstructive hydrocephalus* because of the risk of causing tonsillar herniation and death. Ventricular size can be assessed with a ***computerized tomography (CT) scan*** of the brain.



Note

In tonsillar herniation, also called downward cerebellar herniation, transforaminal herniation, or "coning", the cerebellar tonsils move downward through the ***foramen magnum*** *possibly causing compression of the lower brainstem and upper cervical spinal cord as they pass through the foramen magnum.*

A magnetic resonance imaging (MRI) scan of the brain can provide better anatomical detail of lesions causing hydrocephalus and is particularly useful in the diagnosis of aqueduct stenosis.

In *communicating hydrocephalus*, a lumbar puncture may be both diagnostic, by measurement of opening pressure, and therapeutic, by draining a volume of CSF that allows the closing pressure to be within normal limits.

Management

Management of hydrocephalus will depend on the underlying cause.

Options include:-

1. Removing a causative mass lesion,
2. Ventricular shunting or
3. Third ventriculostomy.

Removing a causative mass lesion

- Intracranial mass lesions may present with obstructive hydrocephalus. In some circumstances it may be appropriate to treat the hydrocephalus by tumour removal and decompression of the CSF pathways, perhaps with the insertion of an **external ventricular drain (EVD)** to cover the early postoperative period.
- In other cases, such as a patient who presents with an impaired conscious level secondary to obstructive hydrocephalus, it may be appropriate to treat the hydrocephalus with an EVD or ventriculoperitoneal shunt and allow the patient to recover before undertaking tumour surgery.

Ventriculoperitoneal shunt

- A ventriculoperitoneal shunt involves the insertion of a **catheter** into the lateral ventricle (usually right frontal or occipital).
- The catheter is then connected to a **shunt valve** under the scalp and finally to a **distal catheter**, which is tunnelled subcutaneously down to the abdomen and inserted into the peritoneal cavity.
- If the CSF pressure exceeds the shunt valve pressure, then CSF will flow out of the distal catheter and be absorbed by the peritoneal lining.

Other options for distal catheter placement include the **right atrium** via the **deep facial** and **jugular vein** (ventriculo-atrial shunt) or the **pleural cavity** (**ventriculopleural shunt**).

<u>Shunt complications</u>

The most common complications include:-

1. Shunt blockage and
2. Infection.

Approximately **15–20%** of shunts are revised **within the first 3 years**.

- **Shunt blockage** may affect the ventricular catheter, shunt valve or distal catheter.
- **Causes of blockage include:-**
    - **a)** Choroid plexus adhesion,
    - **b)** Blood,
    - **c)** Cellular debris or
    - **d)** Misplacement of the distal catheter in the pre-peritoneal space.

Note: More than one-half of cases of shunt blockage are subsequently shown to be infected.

- **Shunt infection** affects between **1% and 7%** of shunt insertions and is usually caused by skin commensals, such as ***Staphylococcus epidermidis***.
- **Neonates** are susceptible to ***Escherichia coli*** and ***haemolytic streptococcal infections***.
- **Risk factors for infection include:-**
    - **a)** Very young children,
    - **b)** Open myelomeningocele,
    - **c)** Longer operative time and
    - **d)** Excessive staff movement into and out of theatre.
- Most infections become apparent clinically **by 6 weeks** and over **90% are apparent within 6 months**.
- Treatment is by removal of the shunt, external CSF drainage and treatment of infection prior to re-insertion of the shunt at a different site. The introduction of antibiotic-impregnated catheters has resulted in a reduction in shunt infection rates.

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