

Cerebral Oedema (Brain Swelling)

What is cerebral oedema?

Cerebral oedema, also known as brain swelling, refers to the abnormal accumulation of water within the brain. It is a life-threatening complication associated with acute neurological conditions such as traumatic brain injury and stroke but may also be associated with more chronic conditions such as brain tumours.

How does brain swelling occur?

Under normal conditions brain water content is tightly controlled to maintain a relatively constant intracranial volume. The blood-brain barrier is a key player in fluid movement into the brain. Normally, the blood-brain barrier acts as a gatekeeper to protect the brain and allow only entry of only certain substances from the blood stream into the brain tissue. However, when the brain becomes injured the blood-brain barrier can become disrupted and the entry of substances into the brain is no longer tightly controlled. This means that the blood vessels become leaky and a number of cascades are initiated that result in an increase in water movement into the brain. It is this net increase in water within the brain that can have serious consequences. Water may also move into cells within the brain, causing them to swell. In this instance this results in a disruption of normal cellular function and puts cells at risk of dying.

Why is cerebral oedema dangerous?

The brain is contained within the bony confines of the skull along with the blood and the cerebrospinal fluid that bathes the brain. Given that the skull is such a rigid structure, any increase in any of the intracranial contents (the brain tissue, blood volume or cerebrospinal fluid volume) must be compensated for by a decrease in one of the other components, otherwise an increase in pressure within the skull will result. Therefore, unlike swelling in other parts of your body, such as when you sprain your ankle and the area swells, gradually subsides and then goes back to normal with no loss of function, swelling in the brain can have deleterious consequences. An increase in pressure within the skull is referred to as increased intracranial pressure. Increased intracranial pressure can be life-threatening as when the pressure can lead to compression of brain tissue and blood vessels, leading to further tissue injury. In severe cases where intracranial pressure continues to rise the brain may herniate down the spinal canal, leading to death due to compression of the respiratory centres within the brain stem.

What are the current treatments?

The aim of treatment is to reduce dangerously elevated intracranial pressure in the first instance and thereby reduce cerebral oedema in the second instance. Some of the currently available treatments are summarised below. Depending upon the nature of the cerebral oedema and the neurological condition, patients may receive one or more of these treatments.

Corticosteroids

These agents aim to reduce inflammation within the brain. They are commonly used in the treatment of cerebral oedema associated with brain tumours.

Mannitol and Hypertonic Saline

These are osmotic agent that draw water out of the brain. The aim of these treatments is to dehydrate the brain by drawing water out of the brain into the blood vessels and thereby reducing brain swelling and intracranial pressure.

Barbituates

This treatment narrows the blood vessels, thereby reducing the blood flow within the brain. In doing so it reduces the electrical activity within the brain and the metabolic demand of the tissue, meaning that the tissue consumes less oxygen and glucose than normal. This treatment is referred to as an “induced coma” and is sometimes employed as precautionary measure pre-empting the onset of cerebral oedema in an attempt to minimise tissue damage. It is only a temporary measure and once the barbituate agents are withdrawn patients will gradually regain consciousness.

Hyperventilation

This treatment increases the breathing rate of patients above normal levels in order to breathe off excess carbon dioxide. Increased levels of carbon dioxide are associated with a swollen brain and increased intracranial pressure. The rationale is that by reducing carbon dioxide levels, the blood vessel and constricted and the volume within the brain is decreased meaning that there is less pressure compressing the brain and intracranial pressure is reduced. However, given that hyperventilation decreases the blood volume within the brain there is a risk of further damage to the brain.

Cerebrospinal Fluid Drainage

Neurosurgeons may elect to insert a drain into the brain in order to remove some of the excess fluid. This drain will remove cerebrospinal fluid, the fluid that bathes the brain, in an attempt to reduce the volume within the skull and reduce the intracranial pressure.

Decompressive Craniectomy

Decompressive craniectomy is surgical procedure where neurosurgeons remove a portion of bone overlying the swollen brain to allow the brain to swell unimpeded and minimise the risk of further injury. Once the brain swelling has subsided the bone flap is replaced. This can be a life saving procedure but is generally only used as a last resort once other measures have failed. It is employed with caution and only a certain subset of patients will eligible for such treatment. Decompressive craniectomy improves blood flow within the brain and the delivery of oxygen and glucose to brain tissue.

What is the prognosis?

Prognosis varies greatly depending upon the associated neurological condition, for example traumatic brain injury and stroke may have different outcomes and prognoses, and also the degree of cerebral oedema, where the more severe or advanced the brain swelling then the increased chance of a poor outcome. Specifically, in the case of stroke cerebral oedema is the most common cause of death within one week of stroke and is a predictor of poor outcome.