Clinical Research in Brain and Neurological Disorders

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A Research Analysis of Cerebral Edema: In Severe Acute Mountain Sickness (AMS)

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Received Date: January 11, 2022; **Accepted Date:** January 28, 2022; **Published Date:** January 30, 2022

Citation: Weiss KH. A Research Analysis of Cerebral Edema: In Severe Acute Mountain Sickness (AMS), J Clinical Research in Brain and Neurological Disorders, V(1)1.

Abstract

Cerebral Edema is excess accumulation of fluid (edema) in the intracellular or extracellular spaces of the brain. This typically causes impaired nerve function, increased pressure within the skull, and can eventually lead to direct compression of brain tissue and blood vessels. Most people who get altitude sickness get AMS, acute mountain sickness. Higher than 10,000 feet, 75% of people will get mild symptoms.

Keywords: Research; analysis; mountain sickness

Introduction

Cerebral edema has been traditional classified into two major sub-types: cytotoxic and vasogenic cerebral edema.This simple classification helps guide medical decision making and treatment of patients affected with cerebral edema.There are, however, several more differentiated types including but not limited to interstitial, osmotic, hydrostatic, and high altitude associated edema. Within one affected person, many individual sub-types can be present simultaneously. The most serious symptoms of altitude sickness arise from edema (fluid accumulation in the tissues of the body). At very high altitude, humans can get either high-altitude pulmonary edema (HAPE), or high-altitude cerebral edema (HACE). The physiological cause of altitude-induced edema is not conclusively established. It is currently believed, however, that HACE is caused by local vasodilation of cerebral blood vessels in response to hypoxia, resulting in greater blood flow and, consequently, greater capillary pressures. On the other hand, HAPE may be due to general vasoconstriction in the pulmonary circulation (normally a response to regional ventilation-perfusion mismatches) which, with constant or increased cardiac output, also leads to increases in capillary pressures. For those with HACE, dexamethasone may provide temporary relief from symptoms in order to keep descending under their own power.

Amyloid-related imaging abnormalities – edema

Amyloid-related imaging abnormalities (ARIA) are abnormal differences seen in neuroimaging of Alzheimer's disease patients given targeted amyloid-modifying therapies. Human monoclonal antibodies such as aducanumab, solanezumab, and bapineuzumab have been associated with these neuroimaging changes and additionally, cerebral edema

Posterior reversible encephalopathy syndrome

Posterior reversible encephalopathy syndrome (PRES) is a rare clinical disease characterized by cerebral edema. The exact pathophysiology, or cause, of the syndrome is still debated but is hypothesized to be related to the disruption of the blood-brain barrier. The syndrome features acute neurological symptoms and reversible subcortical vasogenic edema predominantly involving the parieto-occipital areas on MR imaging.

Idiopathic delayed-onset edema

Deep brain stimulation (DBS) is effective treatment for several neurological and psychiatric disorders, most notably Parkinson's disease. DBS is not without risks and although rare, idiopathic delayed-onset edema (IDE) surrounding the DBS leads have been reported. Symptoms can be mild and nonspecific, including reduction of the stimulation effect, and can be confused for other causes of edema Thus, imaging is recommended to rule out other causes.

Massive brain swelling after cranioplasty

Decompressive craniectomy is frequently performed in cases of resistant intracranial hypertension secondary to several neurological conditions and is commonly followed by cranioplasty. Complications, such as infection and hematomas after cranioplasty occur in roughly about a third of cases Massive brain swelling after cranioplasty (MSBC) is a rare and potentially fatal complication of an uneventful cranioplasty that has recently been elucidated

Radiation-induced brain edema

With the rise of sophisticated treatment modalities such as gamma knife, Cyberknife, and intensity-modulated radiotherapy, a large number of individuals with brain tumors are treated with radiosurgery and radiotherapy. Radiation-induced brain edema (RIBE) is a potentially life threatening complication of brain tissue radiation and is characterized radiation necrosis, endothelial cell dysfunction, increased capillary permeability, and breakdown of the blood–brain barrier.

Diagnosis

Cerebral edema is commonly present in a variety of neurological injuries. Thus, determining a definitive contribution of cerebral edema to the neurological status of an affected person can be challenging. Close bedside monitoring of a person's level of consciousness and awareness of any new or worsening focal neurological deficits is imperative but demanding, frequently requiring admission into the intensive care unit.

Serial neuroimaging (CT scans and magnetic resonance imaging) can be useful in diagnosing or excluding intracranial hemorrhage, large masses, acute hydrocephalus, or brain herniation as well as providing information on the type of edema present and the extent of affected area. CT scan is the imaging modality of choice as it is widely available, quick, and with minimal risks.

Intacranial method monitoring

Intracranial pressure (ICP) and its management is a fundamental concept in traumatic brain injury (TBI).The Brain Trauma Foundation guidelines recommend ICP monitoring in individuals with TBI that have decreased Glasgow Coma Scale (GCS) scores, abnormal CT scans, or additional risk factors such as older age and elevated blood pressure. However, no such guidelines exist for ICP monitoring in other brain injuries such as ischemic stroke, intracerebral hemorrhage, cerebral neoplasm.

Treatment

The primary goal in cerebral edema is to optimize and regulate cerebral perfusion, oxygenation, and venous drainage, decrease cerebral metabolic demands, and to stabilize the osmolality pressure gradient between the brain and the surrounding vasculature. As cerebral edema is linked to increased intracranial pressure (ICP), many of the therapies will focus on ICP

Ventilation and oxygenation

Decreased oxygen concentration in the blood, hypoxia, and increase in the carbon dioxide concentration in the blood, hypercapnia, are potent vasodilators in the cerebral vasculature, and should be avoided in those with cerebral edema. It is recommended that persons with decreased levels of consciousness be intubated for airway protection and maintenance of oxygen and carbon dioxide levels.

Fluid management and cerebral perfusion

Maintenance of cerebral perfusion pressure using appropriate fluid management is essential in patients with brain injury. Dehydration, or intravascular volume loss, and the use of hypotonic fluids, such as D5W or half normal saline, should be avoided.Blood serum ion concentration, or osmolality, should be maintained in the normo to hyperosmolar range.

Acetazolamide 250 mg twice daily dosing assists in AMS treatment by quickening altitude acclimatization. A study by the Denali Medical Research Project concluded: "In established cases of acute mountain sickness, treatment with acetazolamide relieves symptoms, improves arterial oxygenation, and prevents further impairment of pulmonary gas exchange.
Nutritional support is necessary in all patients with acute brain injury. Enteral feeding, or through mouth via tube, is the preferred method, unless contraindicated. Additional attention must be placed on the solute concentration of the formulations to avoid free water intake, decreased serum osmolality, and worsening of the cerebral edema.

Osmotic Therapy

The goal of osmotic therapy is to create a higher concentration of ions within the vasculature at the blood–brain barrier. This will create an osmotic pressure gradient and will cause the flow of water out of the brain and into the vasculature for drainage elsewhere. An ideal osmotic agent produces a favorable osmotic pressure gradient, is nontoxic, and is not filtered out by the blood–brain barrier.

Conclusion

Many studies of the mechanical properties of brain edema were conducted in the 2010s, most of them based on finite element analysis (FEA), a widely used numerical method in solid mechanics. Increased water intake may also help in acclimatizationto replace the fluids lost through heavier breathing in the thin, dry air found at altitude, although consuming excessive quantities ("over-hydration") has no benefits and may cause dangerous hyponatremia.

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