

## Definition:

Physical damage to the brain tissue from trauma or swelling secondary to the initial damage

## Signs:

Altered and reduced consciousness, seizures, bleeding at the eyes, ears or head, heart, difficulty breathing and changes in the pupil size are all common

## Advice:

The outcome depends on the degree of damage as well as the cause of the damage. Causes are really variable ranging from trauma, cancer, infections, blood clots and even immune system abnormalities

## OVERVIEW

- Primary brain injury—result of direct initial injury to the brain (stretch, tear, compression of tissue or vessels)
- Secondary brain injury—alteration of brain blood vessels and tissue (such as bleeding or swelling) that occurs after the primary brain injury
- May be traumatic (external force) or non-traumatic (internal injury caused by low oxygen, infection, toxins, cancer etc.)

## SIGNS/OBSERVED CHANGES IN THE PET

- Decline in the level of consciousness—implies progression from bleeding in the skull (known as “intracranial bleeding”), lack of blood flow to the brain (known as “ischemia”), or fluid buildup within the brain (known as “cerebral edema”)
- Seizure activity
- Evidence of trauma (to the head or other parts of the body)
- Bluish discoloration of the skin and moist tissues (known as “mucous membranes”) of the body (known as “cyanosis”) caused by inadequate oxygen levels in the red blood cells
- Bruising; bleeding into tissues of the eyes
- Blood from the ears or nose—trauma with bleeding into the skull (intracranial bleeding)
- Abnormalities of the skull—fractures of the bones of the skull (may be seen or felt)
- Low body temperature (known as “hypothermia”) or high body temperature (known as “hyperthermia”)
- Slow heart rate (known as “bradycardia”), sometimes seen along with high blood pressure (Cushing’s reflex)

- Bleeding into the back part of the eye (known as the “retina”; condition known as “retinal hemorrhage”)
- Separation of the back part of the eye (retina) from the underlying, vascular part of the eyeball (known as the “choroid”; condition known as “retinal detachment”)
- Heart or breathing abnormalities
- Constricted or dilated pupils—may involve one or both eyes; pupils may be uneven in size; response of the pupils to light may be altered
- Abnormalities of the nervous system; abnormalities can change over time

## CAUSES

- Head trauma
- Prolonged low levels of oxygen (known as “hypoxia”) or decreased or lack of blood flow (ischemia) to tissues in the brain
- Severe low levels of glucose (sugar) in the blood (known as “severe hypoglycemia”)
- Prolonged seizures
- Severe increase in body temperature (hyperthermia) or decrease in body temperature (hypothermia)
- Changes in concentrations of components in the blood (such as sodium or glucose)
- Prolonged shock or low blood pressure (known as “hypotension”)
- Increased blood pressure (known as “hypertension”)
- Migration of parasites through brain tissue
- Inflammatory, infectious and immune-mediated diseases
- Thiamine (a B vitamin) deficiency
- Water on the brain (known as “hydrocephalus”)
- Poisons
- Brain tumor or cancer
- Stoppage of the heart (known as “cardiac arrest”)
- Severe heart failure
- Blood clots to the brain
- Blood-clotting disorders, leading to bleeding in the brain
- Prolonged breathing compromise

## RISK FACTORS

- Free-roaming pet—risk of trauma, exposure to poisons
- Co-existing heart and lung, liver or blood-clotting disease
- Diabetes mellitus (“sugar diabetes”)—insulin therapy

# TREATMENT

## HEALTH CARE

- Goals of therapy: maximize oxygen levels in the brain; support moderate blood pressure and blood flow to the brain; decrease pressure within the skull (known as “intracranial pressure”); decrease rate of metabolism of the brain
- Avoid cough or sneeze reflex during passage of an endotracheal tube into the windpipe or trachea (known as “tracheal intubation”) or oxygen supplementation into the nose—cough or sneeze reflex may elevate pressure within the skull (intracranial pressure)
- Do not block blood flow in the jugular veins
- Modest volume of intravenous fluids will be given to avoid contributing to fluid buildup in the brain (cerebral edema), and to avoid high blood pressure (hypertension)
- A combination of “crystalloids” (these are similar to the liquid partition of the blood, for example a sterile saline solution) with large molecular weight “colloids” may be administered; colloids are fluids that contain larger molecules that stay within the circulating blood to help maintain circulating blood volume, example: hydroxyethyl starch
- Head will be level with body or elevated to a 20°angle; the head will not be positioned lower than the body
- Unobstructed airways will be maintained; using suction and humidifying air if the pet is intubated
- Lubrication will be applied to the eyes as needed
- If the pet is lying on its side, turning the pet about every 2 hours to avoid lung congestion will be done
- Nursing care to prevent secondary complications of recumbency such as fecal/urine soiling and bed sores will be done
- Body temperature maintained at normal temperature
- Maintain hydration with balanced fluid solutions

## ACTIVITY

- Restricted, rehabilitation will include appropriate exercises to maintain muscle tone

## DIET

- Initiate nutritional support to meet increased metabolic demands
- Tube feeding may be required for early nutritional support

## **SURGERY**

- Surgery may be necessary for depressed skull fracture, penetrating foreign body, or computed tomography (CT or CAT scan) or magnetic resonance imaging (MRI) evidence of surgical problem (such as herniation of the brain, fluid buildup in the ventricles of the brain [known as “hydrocephalus” or “water on the brain”], or accumulation of blood [known as a “hematoma”])

## **MEDICATIONS**

Medications presented in this section are intended to provide general information about possible treatment. The treatment for a particular condition may evolve as medical advances are made; therefore, the medications should not be considered as all-inclusive

### **ELEVATED INTRACRANIAL PRESSURE**

- Lower intracranial pressure by increased breathing rate to decrease carbon dioxide levels (known as “hyperventilation”), drug therapy with intravenous concentrated (hypertonic) saline with colloid, drainage of cerebrospinal fluid, or surgical decompression
- Furosemide—a diuretic; decreases production of cerebrospinal fluid (specialized body fluid that cushions the brain and spinal cord) and lowers intracranial pressure; used in pets with conditions such as congestive heart failure, and kidney failure characterized by the lack of production of urine (known as “anuric kidney failure”);
- Mannitol—improves brain blood flow and lowers intracranial pressure; may worsen bleeding in the brain
- Steroids may be used for brain edema associated with cancer or meningitis
- Patient will be provided with pain relievers (known as “analgesics”)/sedatives, as indicated
- Patient will be given therapy to prevent thrashing, seizures, or uncontrolled motor activity—such activity may elevate intracranial pressure; diazepam, midazolam, or propofol may be required
- The patient may receive a loading dosage of phenobarbital, and perhaps a drug called levetiracetam if seizure activity is present
- Medically induced coma (pentobarbital or propofol intravenous) or deep sedation (demedetomidine),—for increased intracranial pressure that does not respond to treatment to lower metabolism in the brain; will pass an endotracheal tube into the windpipe or trachea (intubate) and support blood pressure, oxygenation, and breathing

### **OTHER**

- Cooling the pet down to 32–33°C (89–91°F) may provide brain protection, when done within 6 hours of severe brain injury
- Glucose supplementation—as required for low levels of glucose (sugar) in the blood

(hypoglycemia)

- Careful feeding by tube
- Cisapride or metoclopramide may be necessary to promote digestive tract motility; (known as a “gastrointestinal prokinetic agents”)
- Desmopressin may be considered for high blood sodium

## **FOLLOW-UP CARE**

### **PATIENT MONITORING**

- Repeated nervous system examinations—to detect deterioration of function that warrants aggressive therapeutic intervention
- Blood pressure—keep fluid therapy adequate and avoid high blood pressure (hypertension)
- Blood gases (measurements of oxygen and carbon dioxide levels in arterial blood) and pulse oximetry (a means of measuring oxygen levels in blood) —to assess need for oxygen supplementation or ventilation
- Blood glucose—maintain in the normal range to prevent complications
- Electrocardiogram (ECG, a recording of the electrical activity of the heart)—to detect irregular heartbeats (known as “arrhythmias”) that may affect blood flow and oxygen levels in the brain
- Intracranial pressure—to detect elevations and monitor response to treatment

### **POSSIBLE COMPLICATIONS**

- Seizures
- Brain pushes downward in the skull and has a hernia through the opening that leads to the neck (known as “tentorial herniation” or “brain herniation”), leading to death
- Bleeding inside the skull (intracranial hemorrhage)
- Progression of signs, indicating deterioration of brain injury
- Malnutrition
- Aspiration pneumonia (inflammation/infection of the lungs, caused by accidentally inhaling food, vomit, or liquids)
- Lung congestion (secondary to lying down)
- Drying of the corneas (the clear outer layer of the front of the eye)
- Skin lesions that develop due to contact with urine, when the hair and skin remain damp (known as “urine scald”)
- Airway blockage from accumulation of mucus
- Irregular heartbeats (arrhythmias)—usually involves a slow heart rate (known as “bradyarrhythmias”)
- Low blood pressure (hypotension)
- Increased levels of sodium in the blood (hyponatremia)

- Decreased levels of potassium in the blood (known as “hypokalemia”)
- Breathing failure
- Residual nervous system abnormalities
- Death

## **PREVENTION AND AVOIDANCE**

- Keep pets in a confined area or walk on a leash (avoid trauma and exposure to poisons etc.)

## **EXPECTED COURSE AND PROGNOSIS**

- Young pets, minimal primary brain injury and secondary injury consisting of fluid buildup in the brain (cerebral edema)—best prognosis
- No deterioration of nervous system status for 48 hours—better prognosis
- Rapid resuscitation of systolic blood pressure to greater than 90 mmHg—better outcome
- Use of Glasgow Coma Score (adjusted) may offer prognosis insights

## **KEY POINTS**

- Nervous system signs may worsen before improving
- Prompt treatment and close monitoring are essential
- The extent of brain recovery may not be evident for several days; and may be more than 6 months for residual nervous system deficits to either clear or not

*Blackwell's Five-Minute Veterinary Consult: Canine and Feline, Sixth Edition, Larry P. Tilley and Francis W.K. Smith, Jr. © 2015 John Wiley & Sons, Inc.*