Traumatic Brain Injury

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Introduction

Traumatic brain injury (TBI) is a complex, multifactorial injury resulting from an external force to the head or body. In a 2001 paper in the Journal of the American Veterinary Medical Association vehicular trauma was the most common cause of TBI in canine patients while crush injuries were the most common cause in feline patients. However, patients can present for evaluation of TBI from a wide variety of trauma sources including violence and abuse, penetrating wounds, and falls from height. When evaluating TBI patients it is useful to group the brain injury itself into two groups: primary and secondary brain injury. In addition, understanding the basic pathophysiology will help in guiding care and in developing an accurate prognosis.

Primary Brain Injury

Primary brain injury occurs immediately after the inciting injury and involves direct injury to the brain itself. Examples of primary injury to the brain include laceration, hematoma formation, and diffuse axonal injury. In addition, damage to the brain vasculature and subsequent ischemia at the time of the insult can result in primary brain injury. Generally, treatment options for primary brain injury are limited but may include surgery in situations where there is a space-occupying hemorrhage and/or skull fracture. Therapies aimed at treating TBI are primarily directed at treating secondary brain injury.

Secondary Brain Injury

Secondary brain injury occurs hours to days after a TBI and includes a wide array of biochemical changes that ultimately lead to decreased cerebral perfusion. Secondary brain injury can lead to ischemia, cerebral edema, damage to cerebral vasculature, and ultimately to increased intracranial pressure. Again, most therapies used to treat traumatic brain injuries are aimed at treating secondary brain injury.

Patient Assessment

The patient's examination must focus not only on assessing central nervous system function but also on other body systems, especially in cases presenting following complex trauma (e.g. hit by car). The first priority is to assess the ABC's – airway, breathing, and circulation. The second priority is to perform an overall assessment of the patient in order to identify other injuries sustained in the trauma (e.g. hemoabdomen, pneumothorax, open fractures, etc).

Once a full assessment of the patient has been made a targeted neurological examination should be performed. It is important to assess the patient's mentation (depressed, obtunded, stuporous, comatose); cranial nerve function, especially pupil size, pupillary light response, and oculocephalic reflex; and limb movement and limb pain sensation.

A modified Glasgow coma scale (MGCS) has been developed and evaluated for veterinary patients. The MGCS is useful for assigning an initial score to the patient based on the patient's motor function, brainstem reflexes, and level of consciousness. While the initial MGCS is poorly correlated with survival, evaluating the score over a 24-48 hour period can be predictive of outcome.

After the patient is evaluated a minimum database should be collected including complete blood count, chemistry panel, and urinalysis. In addition, thoracic radiographs should be taken to evaluate for the presence of secondary injuries, such as fractures, pneumothorax, and neurogenic pulmonary edema. Neurogenic pulmonary edema is a common cause of dyspnea in patients suffering from a TBI and is thought to result from the excessive release of catecholamines. It is typically self-limiting but should be identified. Lastly, if there is access to abdominal ultrasound a FAST abdominal ultrasound (focused assessment with sonography for trauma) should be performed to search for potential intra-abdominal injuries sustained during the traumatic event but missed on the initial physical examination.

It is essential to perform serial neurologic examinations, which can be tracked objectively using the MGCS, in addition to constant monitoring of the patient's vital signs.

Pathophysiology and Goals of Treatment

The goal of treatment is to minimize the effects of secondary brain injury by maintaining a normal intracranial pressure. In the case of a space-occupying hemorrhage or skull fracture, surgery may be indicated to treat the primary injury.

Understanding a few simple ideas and equations can help us better employ the treatments for TBI.

Cerebral perfusion pressure (CPP) is the net blood flow to the brain. A patient's CPP is determined by the following equation:

CPP = Mean arterial pressure (MAP) – Intracranial pressure (ICP)

From this equation we can see that if there is an increase in ICP, such as from edema or bleeding within the brain, then the patient's blood pressure (MAP) must increase to maintain blood flow to the brain (CPP). If CPP is not maintained, then cerebral ischemia will occur. The goals of treatment are to maintain CPP by maintaining or increasing MAP and by preventing an increase in ICP.

Treatments

Fluid therapy

Osmotic agents are critical in the treatment of TBI and include mannitol and hypertonic saline. Both agents can be effective at maintaining MAP and reducing ICP. While mannitol remains the first-line osmotic agent, new data suggests that hypertonic saline may provide an overall greater and longer-sustained reduction in ICP compared to mannitol. In most patients either mannitol or hypertonic saline are appropriate choices; however, there are some exceptions. Mannitol should be avoided in patients that are hypovolemic due to the fact that it is an osmotic diuretic and can exacerbate hypotension. Hypertonic saline should be avoided in patients with current or historical hypo- or hypernatremia.

In addition to osmotic agents, it is essential to maintain patients on isotonic fluids in order to maintain adequate blood pressure. Again, maintenance of a patient's blood pressure (MAP) is essential to maintaining cerebral perfusion pressure (CPP) in situations where there is increased intracranial pressure (ICP).

Oxygenation/ventilation

Hypoxia results in decreased cerebral oxygen delivery to the brain and ultimately a worse outcome. Most patients with TBI require oxygen and choosing the correct oxygen delivery system in crucial in TBI patients. For some patients with severe injuries where hypercapnea, hypoxemia, and/or hypoventilation are present, intubation may be needed. In other, less critical situations, placing the patient in an oxygen cage may be sufficient. When choosing the appropriate oxygen delivery method it is essential that coughing (e.g. as may occur with intubation) or sneezing (e.g. with placement of nasal cannulas) be minimized as both can lead to an increase in ICP.

Head elevation

Elevation of the recumbent patient's head at an approximately 30 degree angle will promote venous drainage, thus helping to decrease intracranial pressure.

Pain management

Adequate pain control will help to minimize elevations in intracranial pressure. In most cases of TBI, opioids are the preferred analgesic due to their relatively good safety profile in critical patients.

Anti-convulsant therapy

Seizures are not uncommon following traumatic brain injury and all seizures should be treated. There is debate about whether to treat TBI patients prophylactically for seizures, as is often done in human medicine, but there is no general consensus at this time.

GI protectants
Gastroprotectants, which may include proton pump inhibitors, H2 receptor antagonists, and sucralfate, are recommended in all TBI patients as these patients have several risk factors that predispose them to gastric ulceration.

NO steroids!
Steroids are NOT recommended in cases of traumatic brain injury. Corticosteroids have been associated with a higher mortality rate in cases of human TBI.

Supporitve Care
Supportive care, including nutrition and proper nursing care, should be considered in each patient in a case by case manner.

Imaging
Skull radiographs, CT, and/or MRI may be necessary in patients that have obvious open skull fractures; those that do not respond to treatment; or those that initially respond to medical therapy but subsequently deteriorate. Imaging may reveal an ongoing cause of primary brain injury (e.g. space-occupying hemorrhage, skull fractures) that may need to be treated surgically.

Surgery
Surgery may be indicated in patients with open skull fractures; those with hemorrhage (e.g. intraparenchymal hematoma, epidural hematoma) that requires evacuation; or in those with intracranial foreign bodies resulting from the initial trauma.

Prognosis
Because multiple body systems are often affected in patients with traumatic brain injury, it is essential to base the prognosis on a case by case situation. It is important to monitor a patient with serial examinations and to base the prognosis on trends (e.g. the direction that the modified Glasgow coma scale is trending) rather than on a single, initial examination.

Conclusion
Treatments for TBI are generally aimed at secondary brain injury; however, in some cases surgery may be used to treat primary brain injury, especially in cases of skull fractures or space-occupying hemorrhage. Treatments are aimed at maintaining cerebral perfusion pressure (CPP). This goal can be achieved by maintaining or increasing mean arterial pressure (MAP) and by decreasing intracranial pressure (ICP). When evaluating a TBI patient it is important to remember that these patients often have concurrent injuries with multiple body systems affected. Cases of TBI are dynamic cases and prognosis must be made based on concurrent injuries as well as the direction in which the patient is trending. The modified Glasgow coma scale (MGCS) is a useful grading system for objectively evaluating a patient's neurologic status and for tracking that status over time.

Selected References:

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