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The consequences of raised intracranial pressure in dogs and cats

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ABSTRACT: As a neurology nurse at a referral centre, nursing both canine and feline patients with intracranial disease is quite a common occurrence. It is important to understand how the body is affected and therefore recognise clinical signs that are portrayed in patients, at risk of or those suffering from raised intracranial pressure (ICP). If left untreated, the animal can suffer detrimental effects such as brain herniation and death. The article will discuss many nursing skills that can help nurses recognise these clinical signs and also tips to prevent a further increase in ICP both in the conscious and anaesthetised patient.

Keywords: ICP; herniation; brain; nursing; MGCS

What is intracranial pressure (ICP)?

Brain tissue, cerebrospinal fluid (CSF) and blood are the three components within the cranial cavity surrounded by the rigid bony skull. ICP is the pressure inside the skull, which is influenced by the equilibrium between these components (Platt & Olby, 2013). In the healthy patient, compensatory mechanisms maintain a constant Insert Intercranial Pressure (ICP), meaning that an increase in volume of any of the three intracranial compartments will result in an equivalent decrease in the other two. These compensatory mechanisms may fail and vary in presence of different intracranial diseases (for example tumour, head trauma, inflammation). Normal ICP is between 5–12 mmHg (Platt & Olby, 2013).

An example is in a patient with acute head trauma, the compensatory changes may not happen fast enough as they are disrupted due to the sudden injury and therefore cannot cope with the increase in central nervous system (CNS) volume due to oedema, haemorrhage or CSF accumulation, therefore an increase in ICP is more likely. The ability to compensate is instead more effective if the increase in volume occurs slowly, like in the presence of brain tumours. In these cases, the compensatory mechanisms may be able to prevent a rise in ICP initially, but will eventually fail and progressive increase in intracranial volume will dramatically increase ICP (Platt & Olby, 2013). High ICP may be life threatening, therefore any patient with intracranial disease should be recognised promptly and managed appropriately to prevent any further increase in ICP, of which a detrimental consequence is brain herniation (Bagley and Platt, 2013).

Brain herniation

Brain herniation is when structures in the brain move from their normal position in the skull. There are five types of brain herniation; caudal transtentorial and foramen magnum are the most clinically relevant (Lewis et al., 2016). Transtentorial herniation causes compression of the mid brain and the nucleus of cranial nerve III which affects pupil size and responsiveness to light (Bagley and Platt, 2013). Foramen magnum herniation occurs when the caudal cerebellum herniates into the foramen magnum, clinically the respiratory centres are affected and can prevent the patient from breathing voluntarily (Bagley and Platt, 2013). Magnetic resonance imaging (MRI) is widely used to detect intracranial disease and therefore has increased the frequency of diagnosing brain herniation in dogs and cats (Lewis et al., 2016).

Figure 1. Hartmanns, mannitol, hypertonic saline.

Clinical and neurological signs of increased ICP

Evaluation of the mental status, ability to move, pupil size and responsiveness, position and movement of the eyes and breathing pattern is critical in the identification of patients with increased ICP. Lack of coordination, loss of balance, inability to walk, seizures, anisocoria are all clinical signs that can be present in these patients.

Establishing a patient's demeanour and level of consciousness is an essential part of the neurological examination that provides information regarding brain function, the level of injury and signs of raised ICP (Platt, 2015). The mental status of an animal can be described as normal, depressed, stuporous, or comatose. The interpretation of each mental status are as follows;

Normal – alert and responsive to all stimuli.

Depressed – reduced level of consciousness but responds appropriately to stimuli.

Stuporous – unresponsive to environmental stimulation but responsive to painful stimulation.

Comatose – non-responsive to both environmental and painful stimulation (Bagley and Platt, 2013).

Pupil size, shape and reactivity are an important aspect of the patient's physical examination and should be assessed at frequent intervals to be able to monitor any deterioration or improvement if the patient has started treatment. Pupillary abnormalities can be unilateral or bilateral (Platt, 2015).

Bradycardia, hypertension and irregular respiration are warning signs of raised ICP, referred to as the Cushing reflex and immediate treatment is essential to prevent further cerebral damage such as herniation and neurological deterioration (Fodstad, Kelly and Buchfelder, 2006). The Cushing reflex is a physiological nervous system response to an increase in ICP, which decreases cerebral blood flow resulting in an accumulation of carbon dioxide. This causes vasodilation in the brain elevating ICP further, followed by an increase in systemic blood pressure in an attempt to compensate and increase cerebral perfusion. Carotid baroreceptors identify the sudden increase in systolic blood pressure resulting in a reflex bradycardia (Syring, 2005).

Fluid therapy

Fluid therapy is a very important management tool for patients with raised ICP. The aim is to ensure the patient has an adequate cerebral perfusion pressure by maintaining a normovolaemic state (Platt & Olby, 2013).

Crystalloids: patients suffering from head trauma or those with intracranial tumours require a normovolaemic state to ensure adequate cerebral perfusion pressure.

Hypertonic saline: is also a crystalloid and removes fluid from the interstitial and intracellular spaces into the intravascular space. This in turn restores the blood volume improving systemic blood pressure, cerebral blood pressure and flow, therefore decreasing ICP (Platt & Olby, 2013). It has a volume expansion effect that only lasts up to 75 minutes (Sande and West, 2010). Recommended doses are 4 ml/kg of 7.5% sodium chloride over 2-5 minutes (Sande and West, 2010).

Mannitol: is an osmotic diuretic that also removes fluid from the interstitial and intracellular spaces into the intravascular space. This has an immediate plasma expanding effect which reduces blood viscosity, leading to improved oxygen delivery, stimulating cerebral vasoconstriction thus causing a decrease in ICP. The recommended dose ranges are between 0.5-1.5g/kg as a bolus over 15-20 minutes in order to obtain the plasma expanding effect (Platt & Olby, 2013). The effect can last up to 8 hours (Sande and West, 2010).

If a raised ICP is suspected, it is preferable to administer mannitol or hypertonic saline before the patient undergoes further investigations that involve anaesthesia. To ensure systemic dehydration does not occur, it is important to remember to administer isotonic crystalloids at a maintenance rate for the patient following hypertonic solutions (Platt & Olby, 2013). These fluids should be used with caution in patients with underlying cardiac or respiratory disease.

Nursing considerations

There are a number of simple precautions that can be taken and patient checks that can be performed when nursing patients with raised ICP:

- **Avoid pressure around the neck** – This can cause obstruction of the jugular veins and therefore contribute to increased ICP: jugular venepuncture and neck leads should therefore be avoided; blood sampling from peripheral veins or harnesses for walks should be used as an alternative. Significant increases in ICP were evident secondary to increasing jugular occlusion in a study on intracranial pressure monitoring (Sturges et al., 2019).
- **Consider patient positioning** – In the recumbent patient with suspected head trauma or risk of increased ICP, the head should be elevated at a 30-degree angle (Platt & Olby, 2013); head down positioning increases cerebral venous blood volume and as a result increased ICP. Elevating the head encourages emptying of the venous sinuses, thus preventing excessive cerebral blood flow (Lorenz & Kornegay, 2004).
- **Bladder management** – This is an important nursing consideration as patients will often pass a large volume of urine after administration of fluids such as mannitol. It is important to ensure they are comfortable. Patients that are able to ambulate should be walked and those who are recumbent or comatose will need regular bed checks and may even require the nurse to perform manual bladder expression depending on their mentation.
- **Monitor respiration** – Respiratory parameters include respiration rate and effort, mucous membrane colour and thoracic auscultation. Hypoventilation causes hypercapnia leading to vasodilation and thus increased ICP (Lorenz & Kornegay, 2004). The respiratory system can be affected following traumatic injuries not only due to thoracic compromise but also to cerebral impairment; oxygen supplementation should therefore be considered in all patients with acute brain injury (Platt and Olby, 2015). Oxygen can be provided via flow by or via nasal prongs, the method of oxygen delivery should provide minimal stress to the patient which can further increase ICP (Platt & Olby, 2013). Pulse oximetry can also help determine the patient's oxygenation status and is recommended to be 95% or higher (Platt & Olby, 2013).
- **Monitor heart rate and blood pressure** – These vital parameter checks are recommended for patients at risk of raised ICP in order to help prevent clinical

Score	Motor activity
6	Normal gait, normal spinal reflexes
5	Hemi-paresis, tetra paresis or decerebrate activity
4	Recumbent, intermittent extensor rigidity
3	Recumbent, constant extensor rigidity
2	Recumbent, constant extensor rigidity with opisthotonus
1	Recumbent, hypotonia of muscles, depressed or absent spinal reflexes

Score	Brain stem reflexes
6	Normal PLR and oculocephalic reflexes
5	Slow PLR and normal to reduced oculocephalic reflexes
4	Bilateral un reactive miosis with normal to reduced oculocephalic reflexes
3	Pinpoint pupils with reduced to absent oculocephalic reflexes
2	Unilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes
1	Bilateral, unresponsive mydriasis with reduced to absent oculocephalic reflexes

Score	Level of consciousness
6	Occasional periods of alertness and responsive to environment
5	Depression or delirium, capable of responding but response may be inappropriate
4	Semi-comatose, responsive to visual stimuli
3	Semi-comatose, responsive to auditory stimuli
2	Semi-comatose, responsive only to repeated noxious stimuli
1	Comatose, unresponsive to repeated noxious stimuli

Figure 2. Modified Glasgow coma scale.

deterioration as early as possible. Bradycardia in addition to hypertension can be indicative of an increase in ICP, it is therefore of great importance to closely monitor these parameters. (Refer to Cushing reflex).

- **Modified Glasgow coma scale (MGCS)** – This is a useful tool in veterinary medicine when treating patients with or at risk of raised ICP. It consists of a scoring system to grade the neurological status of the patient initially and also throughout their treatment. It is divided into 3 sections; motor activity, brainstem reflexes and level of consciousness. Each section is scored from 1 – 6, 1 being the most severe and 6 being the mildest clinical sign. The total score can then help estimate the severity of the patient's condition, which in turn determines the prognosis (For example MGCS < 14 is associated with a guarded prognosis; MGCS < 8 associated with a grave prognosis) and the requirement of specific treatment (Platt, 2015). A suggested goal is for the patient to remain above 15 (Platt & Olby, 2013). (See Figure 2). It should be taken into consideration, that the influence of medication can also affect the patients score, heart rate or blood pressure, for example if they are receiving sedatives or opiates.
(Please refer to the brainstem reflexes section of the MGCS).
- **Pain management** – Recognising pain is an essential skill for nurses to have and providing analgesia with direction of the veterinary surgeon is a big part of a veterinary nurses job. Patients with head trauma will require analgesia, normally in the form of opiates and this can also prevent further elevation of ICP (Sande and West, 2010). Opioids do have adverse effects such as respiratory depression and hypotension which can increase ICP, they are safe to use if titrated to achieve adequate analgesia (Platt & Olby, 2013).
- **Anaesthetic considerations** – Pre-oxygenation via flow by or a mask if tolerated for 5-10 minutes is recommended prior to induction of anaesthesia, to prevent hypoxaemia (Raisis & Musk, 2013). Preventing coughing during tracheal intubation is important as this can increase ICP. This is applicable during both intubation and extubation for those patients undergoing anaesthesia. Minimising laryngeal stimulation during intubation can be achieved, by ensuring the patient has reached an adequate level of anaesthesia during the induction process before attempting to intubate and also by utilising lidocaine spray on the larynx (Raisis & Musk, 2013). Sevoflurane is the recommended inhalation agent as it has a minimal effect on increasing ICP (Raisis & Musk, 2013). During the anaesthetic, ensuring the patients end tidal carbon dioxide ($ETCO_2$) is not increased will also help prevent any further rise in ICP (Sturges et al., 2019).

Conclusion

Nursing a patient with, or at risk of raised ICP can be challenging but also very rewarding especially if they make a full recovery. There are many nursing considerations to be acknowledged, all of which contribute in some way to a patient's recovery, highlighting the importance of a veterinary nurse. The author finds nursing patients with intracranial disease extremely interesting and learns something new from every patient.

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