Introduction to the Nervous System

Nervous System Classification

Animals have a complex nervous system. It receives and interprets the signals from the surroundings, and sends the messages to the brain. The structure of the nervous system depends upon the body plan of an organism e.g. animals that do not have a defined head or tail, they have web-like arrangements of nerve cells throughout the body. Animals with a defined head have the nervous system divided into three parts: the Central Nervous System, Peripheral Nervous System, and Autonomous Nervous System.

1. Central Nervous System– It comprises of the brain and neurons. It is located in the head and continues along the back
2. Peripheral Nervous System– It includes all the nerves continuing from the central nervous system to the entire body.
3. Autonomous Nervous System– It consists of sympathetic and parasympathetic nerves.

In all the vertebrates, the central nervous system comprises the brain and the spinal cord. The brain contains centers that process the signals received, regulate the homeostasis, and control emotions and intelligence.

The spinal cord helps in the transfer of information to and from the brain.

Explore more about Nervous System

Nervous System Functions

The nervous system consists of different parts performing different functions, listed below are the functions of various parts.

Nervous System Parts And Functions

Brain

The brain consists of the following parts performing the following functions:

1. Cerebral Cortex – Voluntary movement, reasoning, language, perception and thought are a few functions.
2. Cerebellum – It is involved in maintaining balance, movement and body posture. The cerebellum is split into two hemispheres wherein the cortex envelopes the hemispheres.
3. Hypothalamus – This region is responsible for the regulation of the temperature of the body, hunger centre, emotions, regulation of the circadian rhythms etc. It serves as a thermostat which senses the body temperature and projects signals to manage the temperature.
4. Medulla oblongata or Brain stem – It controls heart rate, breathing and blood pressure and consists of the pons, medulla, tectum, tegmentum and reticular formation.
5. Thalamus – It integrates the motor and sensory information and obtains the sensory information which inturn carries forward the information to the cerebral cortex. The information it receives from the cerebral cortex is transmitted by it to the other areas of the spinal cord and the brain
6. Limbic system – It assists in regulating the response to emotions and includes the hippocampus, cingulate gyrus and mammillary bodies. The hippocampus is vital for memory and learning.
7. Basal Ganglia – It regulates the movements and balance and includes the caudate nucleus, globus pallidus, putamen, substantia nigra and subthalamic nucleus.

8. Midbrain – It controls hearing, vision, body movement, eye movement. It consists of the red nucleus, inferior and superior colliculi.

Cerebrospinal Nervous System

It consists of 12 pairs of cranial nerves which are connected to the brain having particular functions. The following are the nerves and their respective functions:

1. Optic – Sight
2. Oculomotor – Eyeball, pupils and lens movement
3. Olfactory – Smell
4. Trochlear – Motion of the eye muscles (superior oblique)
5. Trigeminal – Supplies with nerves for eyes, jaws, cheeks and governs chewing
6. Abducens – Outward gaze, movement of the lateral rectus muscles in humans
7. Facial – movement of the facial muscles, regulates salivary glands, taste sensation from the anterior of the tongue
8. Glossopharyngeal – Sensation of taste
9. Acoustic – Maintains balance, hearing
10. Vagus – Supplies with nerves for the organs in the abdomen and the chest
11. Spinal Accessory – Shoulder and head movement
12. Hypoglossal – Regulate muscles of the tongue

Autonomic Nervous System

This system is segregated into parasympathetic and sympathetic nervous systems which have contrasting effects on the same organ set. The parasympathetic nervous

system is linked with a relaxed condition such as the contraction of the pupils, slowing of the heart rate, energy for food digestion etc.

The sympathetic nervous system is necessary during a crisis and is linked with "fight or flight reaction". Increased rate of breathing, pupil dilation, Increase in the heart rate, Increased rate of salivation and perspiration etc.

Parts of Nervous System

Neuron

A neuron is the structural and functional unit of a nervous system. It has the capacity to receive and dispatch electrochemical signals. They have three basic parts:

Cell Body

This is the main part of the neuron and consists of a nucleus, mitochondria, endoplasmic reticulum, and ribosomes. If the cell body dies, the neuron does not survive.

Axon

An axon or a nerve cell is a long cylindrical structure that conducts nerve impulses away from the cell body. It is covered with a thin layer of insulated electrical wire known as myelin. Myelinated neurons are found in the peripheral nervous system, while non-myelinated neurons are found in the brain and the spinal cord.

Dendrites

These are located on either side of the neuron. These are small branch-like projections used to connect with the adjacent neuron.

Also read: Neuron

Types Of Nerves

When several axon fibres are bundled together they form a nerve. Nerves are of three types:

Sensory

When the direction of impulse is from the receptor to the brain or spinal cord, the nerve fibres are called sensory. For eg., nerves in the eyes, nerves, and ears.

Motor

When the impulse is directed from the brain or spinal cord to the gland or muscle, it is known as a motor neuron.

Mixed

A mixed nerve contains both the sensory and the motor nerves. For eg., spinal nerves

Also refer: Nerves

Parts of Brain

The brain receives signals from the sense organs and transmits them back to the nerves. The brain is placed in the skull which contains the cerebrospinal fluid to protect the brain from any mechanical shocks. It is divided into three regions:

Forebrain

It receives the impulses from the receptors. It has specific areas to analyze the different signals like hearing, smelling, etc. The process of thinking also takes

place here. The incoming signals are interpreted and transmitted to the respective regions.

Midbrain

Our body performs various voluntary and involuntary functions. Voluntary actions like running and pushing are under human control. Involuntary actions such as blinking, breathing are automatic, and not under human control.

Hindbrain

The hindbrain contains the medulla and the cerebellum. These control breathing, salivation, blood pressure. .

NEUROLOGICAL EXAMINATION IN SMALL ANIMALS

The aims of the neurological examination is to
answer the following questions:

1. Are we dealing with the primary neurological condition or not? So is this the neurological condition, or the condition affecting the function of
the nervous system, or is this a completely different condition (orthopaedic, cardiovascular etc.)?
2. Can we localise the lesion within the nervous system?
3. What are the most common differential diagnoses?
4. How severe is the condition?

Neurological examination steps

A - History, It is very important to take a thorough history as this can give many clues in making the most likely differential diagnoses. It is important to know species, breed, sex and age of animals before taking the history.

B - Physical examination

Complete physical examination needs to be performed before the neurological examination. It is of upmost importance to do so as many conditions that are not primarily neurological can be discovered here and the diagnostic work-up can take a different direction or can alter the final prognosis.

1- *Hands off examination:* This part of the neurological examination can be performed while collecting the history. The patient should be left to explore the examination room. The clinician can observe the wareness, behavior, posture and gait in an undisturbed manner.

2- *Consciousness*, awareness, behavior: State of consciousness is classified in order of severity as lethargy, depression, obtundation,

stupor (semicoma) and coma. Generally if there is an altered state of consciousness then the lesion is affecting either diffusely both cerebral hemispheres or focally the ascending reticular activating system (ARAS) of the brainstem.

3- *Posture and body position*: Observation of the posture and body position at rest can reveal mild asymmetry and can also assess the balance at the stance. Common abnormalities

a- Head tilt

b- Head turn

c- Ventrofl exion of the head

d- Spinal curvature

e- Decerebellate posture

4- *Evaluation of gait*: Abnormalities of the gait are one of the most common reasons to seek veterinary advice. It is therefore important to assess whether the animal is uncoordinated (ataxia), has an abnormality in the strength of voluntary movement (paresis) or is lame (neurological or orthopaedic).

5- *Cranial nerve examination Olfactory Nerve – (CN I)* It is generally difficult to asses the smell in small animals and in a majority of cases it is the owners who complain about the loss of smell (anosmia) rather than the finding on neurological examination. Letting the animal to sniff something aromatic while blindfolded can test the smell.

6- *Optic Nerve (CN II)*: This is not a peripheral nerve by strict defi nition but it is the extension of the brain. CNII is an important central visual pathway and it is afferent for menace response and pupillary light reflex (PLR).

7- *Oculomotor Nerve (CN III)* This nerve innervates ipsilateral dorsal, ventral and medial recti muscles and ventral oblique muscle. It also innervates the levator palpebrae superioris muscle which is important for upper eyelid movement. And fi nally the oculomotor nerve plays an important role as an efferent arm of PLR. It controls the pupillary constriction by its parasympathetic component.

8- *Trochlear nerve (CN IV)* This is assessed by observing the position of the eyeball as well as by testing for physiological nystagmus. This nerve innervates contralateral dorsal oblique muscle. Dysfunction usually results in dorsolateral strabismus of the contralateral eye.

9- *Trigeminal nerve (CN V)* The trigeminal nerve provides sensory innervation of the face as well as motor innervationof the masticatory muscles.

10- *Abducent nerve (CN VI)* This nerve innervates the ipsilateral lateral rectus and retractor bulbi muscles. The assessment is therefore done by observation of the eye position, testing the physiological nystagmus and by corneal reflex (retracting of the eyeball).

11- *Facial nerve (CN VII)* This nerve provides motor function to the muscles of the face and sensory function to the rostral two thirds of the tongue and palate. The facial nerve also carries the parasympathetic component that innervates the lacrimal glands, and mandibular and sublingual salivary glands.

12- *Vestibulocochlear nerve (CN VIII)* This nerve is involved in hearing and vestibular function. The vestibular system consists of the peripheral part (special proprioceptors in the inner ear and vestibular nerve) and central part (four nuclei in the brainstem and part of cerebellum). The hearing part involves the sensory receptors in the cochlea (inner ear).

13- *Glossopharyngeal nerve (CN IX) and Vagus nerve (CN X)* These two cranial nerves share the same motor and sensory nuclei in the brainstem. The glossopharyngeal nerve supplies the musculature of the pharynx and palate and it provides sensory innervation to the caudal third of the tongue and pharyngeal mucosa.

14- *Accessory nerve (CN XI)* This nerve supplies motor innervation to the trapezius, sternocephalicus and brachiocephalicus muscles and so the dysfunction results in atrophy of these muscles and potential deviation of the neck. However isolated lesions of this nerve are rare.

15- *Hypoglossal nerve (CN XII)* This nerve innervates the muscles of the tongue. Function of this nerve can be assessed by observingfor symmetry of the tongue and movement of the tongue during the eating, or licking of food. Lesions of

this nerve result in problems with prehension and mastication. Asymmetry of the tongue and fasciculation of the musculature of the tongue can also be seen.

Spinal cord injury

Spinal Cord Trauma: The spinal cord is protected within the spinal column, which is composed of small bones called *vertebrae* . The spinal cord transmits neurologic information between the brain and the rest of the body. Spinal cord trauma can cause neurologic abnormalities and pain.

Causes

The most common causes are automobile accidents. Other causes include falling from a height or being struck by an object. Trauma to the spinal column may cause fractures or luxations (dislocations of the spine) that result in bruising, bleeding into, or compression of the spinal cord.

Clinical Signs

Signs are dependent on the area of spinal cord affected and the severity of the trauma. Often, other areas of the body are also injured, with loss of blood (hemorrhage), internal organ damage, broken bones, and/or trauma to the heart and lungs. Neurologic abnormalities vary with the degree of spinal cord injury

Diagnostic Tests

Routine laboratory tests may be recommended to evaluate for blood loss and organ damage associated with the trauma. X-rays are used to evaluate injury to the chest, abdomen, and other bones. X-rays of the spine may show a fracture, luxation, or malalignment of the spine. Additional imaging with computed tomography (CT scan) or magnetic resonance imaging (MRI) may be recommended to further evaluate the vertebrae and spinal cord. CT scans show more detailed images of

bone that may be used for planning surgery in cases of fracture or dislocation. MRI allows detailed evaluation of the spinal cord for damage or compression.

Treatment Options

Animals with spinal cord trauma may be treated conservatively or surgically, depending on the severity of the signs and the stability of the spine. Conservative therapy is typically recommended when neurologic signs are mild and the spine appears on imaging studies to be stable and properly aligned. Animals with mild injuries may be treated with exercise restriction and medication. Occasionally splints (back braces) are used to

help support the spine. Exercise restriction involves strict confinement

to a crate and leash walking only to allow the animal to urinate and defecate. Cats are confined in a small area with a litter box. Animals cannot be allowed to run, jump, or play during their confinement. Exercise restriction usually lasts 4-6 weeks, with gradual return to normal activity at the end of the confinement period. Anti-inflammatory medications, such as non-steroidal anti-inflammatory drugs or steroids, can be used, but these two classes of drugs are not used together because of their combined side effects. Pain medications may be needed to keep the animal comfortable.

Sciatic Nerve Injury

Sciatic nerve injuries associated with acetabular fractures may be a result of the initial trauma or injury at the time of surgical reconstruction. Patients may present with a broad range of symptoms ranging from radiculopathy to foot drop. There are several posttraumatic, perioperative, and postoperative causes for sciatic nerve palsy including fracture dislocation of the hip joint.

A ventral median skin incision extending from the caudal third of the abdomen to the caudal border of the pubis was performed. The caudal part of the linea alba was

opened and the incision was prolonged caudally through the prepubic tendon to the surface of the pubic symphysis. The gracilis and adductor muscles were elevated from the pubic symphysis using a Langenbeck periostal elevator. The ischium and pubis were then osteotomized using an oscillating saw. The first osteotomy was performed bilaterally from the iliopubic eminence to the craniolateral aspect of the obturator foramen. The second bilateral osteotomy was performed from the caudolateral aspect of the obturator foramen to the lateral edge of the sciatic arch. The osteotomized pubis and ischium were removed, and the lumbosacral trunk was identified running medially to the body of the ilium. The diameter of the lumbosacral trunk was determined with a Vernier Caliper, taking care to avoid displacement of the nerve during measurement, and a simple suture (5-0 Prolene) was placed on the lateral aspect of the lumbosacral trunk at the level of the midbody of the ilium determined by palpation.