Central Nervous System Overview

Nervous System · https://anesthesiabraintrust.org/docs/central-nervous-system-overview/

Introduction

The central nervous system (CNS) of dogs and cats is a complex and highly specialized structure responsible for coordinating sensory input, processing information, and initiating motor output. It consists of the brain and spinal cord, working together to regulate bodily functions and respond to environmental stimuli. Understanding the anatomy, physiology, and functional testing of the CNS in these species is essential for diagnosing and treating neurological disorders.

Anatomy of the Central Nervous System

Brain

The brain is the command center of the CNS and is divided into the cerebrum, cerebellum, and brainstem. Each region has specific roles in maintaining homeostasis, coordinating movement, and processing sensory information.

Cerebrum

The cerebrum is the largest part of the brain and is responsible for conscious thought, sensory perception, and voluntary motor functions. It is divided into two hemispheres by the longitudinal fissure and further subdivided into lobes:

- **Frontal lobe**: Involved in motor control, problem-solving, and behavior.
- **Parietal lobe**: Processes sensory information such as pain, touch, and proprioception.
- **Temporal lobe**: Plays a role in hearing and memory.
- **Occipital lobe**: Responsible for vision processing.

Cerebellum

The cerebellum is located caudal to the cerebrum and plays a crucial role in balance, coordination, and fine motor control. Damage to the cerebellum results in ataxia, tremors, and loss of coordination.

Brainstem

The brainstem connects the brain to the spinal cord and regulates vital autonomic functions such as respiration, heart rate, and digestion. It is composed of the midbrain, pons, and medulla oblongata.

- **Midbrain**: Controls visual and auditory reflexes.
- **Pons**: Contains pathways for communication between the cerebrum and cerebellum.
- **Medulla oblongata**: Regulates autonomic functions such as respiration and cardiovascular control.

Spinal Cord

The spinal cord is a cylindrical structure extending from the brainstem down the vertebral column, facilitating communication between the brain and peripheral nerves. It is divided into segments:

- **Cervical (C1-C8)**
- **Thoracic (T1-T13 in dogs, T1-T12 in cats)**
- **Lumbar (L1-L7 in dogs, L1-L7 in cats)**
- **Sacral (S1-S3)**
- **Caudal (variable number of segments)**

The spinal cord contains both gray matter, where neuronal cell bodies reside, and white matter, which consists of myelinated nerve fibers transmitting signals.

Physiology of the Central Nervous System

Neuronal Communication

Neurons are the fundamental units of the CNS, transmitting information via electrical and chemical signals. Key processes include:

- **Action Potentials**: Electrical impulses generated by changes in membrane potential.

- **Synaptic Transmission**: Chemical communication between neurons using neurotransmitters such as acetylcholine, dopamine, and serotonin.

Reflexes and Sensory Processing

The CNS processes sensory input from the peripheral nervous system (PNS) and generates appropriate motor responses. Reflex arcs, such as the patellar reflex, allow for rapid, involuntary responses to stimuli.

Autonomic Nervous System Integration

The autonomic nervous system (ANS) regulates involuntary functions through its two subdivisions:

- **Sympathetic Nervous System**: Prepares the body for stress-related activities ("fight or flight").
- **Parasympathetic Nervous System**: Promotes rest and digestion ("rest and digest").

Cerebrospinal Fluid (CSF) and Blood-Brain Barrier (BBB)

- **CSF**: Provides cushioning and nutrients to the CNS and removes waste products.
- **BBB**: A selective permeability barrier that protects the CNS from toxins and pathogens.

Functional Testing of the Central Nervous System

Neurological Examination

A comprehensive neurological exam is essential for assessing CNS function. Key components include:

1. Mental Status and Behavior

- Assessing alertness, response to stimuli, and changes in behavior.
- Abnormalities may indicate forebrain or brainstem dysfunction.

2. Cranial Nerve Examination

Evaluation of cranial nerves (CN I-XII) provides insight into specific brainstem functions:

- **CN I (Olfactory)**: Sense of smell.
- **CN II (Optic)**: Vision (tested with menace response and pupillary light reflex).

- **CN III (Oculomotor), IV (Trochlear), VI (Abducens)**: Eye movement and pupil constriction.
- **CN V (Trigeminal)**: Facial sensation and mastication.
- **CN VII (Facial)**: Facial expression and tear production.
- **CN VIII (Vestibulocochlear)**: Hearing and balance.
- **CN IX (Glossopharyngeal) and X (Vagus)**: Swallowing and vocalization.
- **CN XI (Accessory) and XII (Hypoglossal)**: Neck movement and tongue control.

3. Postural Reactions

Tests to assess proprioception and coordination include:

- **Hopping**: Evaluates limb strength and proprioception.
- **Wheelbarrowing**: Tests forelimb coordination.
- **Hemistanding/Hemiwalking**: Assesses lateralized CNS dysfunction.
- **Paw Placement (Knuckling Response)**: Indicates proprioceptive deficits.

4. Spinal Reflexes

Evaluating spinal reflexes helps localize lesions in the spinal cord:

- **Patellar Reflex**: Tests femoral nerve and L4-L6 spinal cord segments.
- **Withdrawal Reflex**: Evaluates function of C6-T2 (forelimb) and L6-S1 (hindlimb).
- **Perineal Reflex**: Tests sacral spinal cord segments (S1-S3).

5. Gait and Posture Evaluation

Observing the animal’s gait and posture can identify neurological deficits such as:

- **Ataxia**: Uncoordinated movements due to cerebellar or proprioceptive dysfunction.
- **Paresis or Paralysis**: Weakness or complete loss of voluntary movement.
- **Circling**: Suggests forebrain lesions.

Advanced Diagnostic Testing

When clinical examination suggests CNS dysfunction, further diagnostic tests are warranted:

Imaging Studies

- **Magnetic Resonance Imaging (MRI)**: Provides detailed images of brain and spinal cord structures.
- **Computed Tomography (CT)**: Useful for detecting fractures, hemorrhages, or masses.
- **Myelography**: Involves contrast dye injection to highlight spinal cord abnormalities.

Electrodiagnostic Testing

- **Electroencephalography (EEG)**: Evaluates brain electrical activity in seizure disorders.
- **Brainstem Auditory Evoked Response (BAER) Test**: Assesses auditory function and brainstem integrity.

Cerebrospinal Fluid (CSF) Analysis

CSF evaluation can help diagnose inflammatory, infectious, or neoplastic CNS diseases.

References

- Dewey, C. W. (2016). *A Practical Guide to Canine and Feline Neurology*. Wiley-Blackwell.
- Platt, S. R., & Olby, N. J. (2013). *BSAVA Manual of Canine and Feline Neurology*. BSAVA.
- Lorenz, M. D., Coates, J. R., & Kent, M. (2011). *Handbook of Veterinary Neurology*. Elsevier.