Neurology the Fun Way Video Case Presentations (Cats)

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"To move is all mankind can do, and for such the sole executant is muscle, whether in whispering a syllable, or in felling a forest"
Sir Charles Sherrington, 1924

The fundamental structural units of the nervous system are its cells (neurons and glia) and the fundamental functional units of the reflex arcs into which the neurons are organized. Most introductions to the neurosciences deal extensively with the details of cellular, axonal, and synaptic physiology to describe the mechanisms by which these basic units operate to allow the nervous system to accomplish its functions. This approach to the subject is entirely correct and justified because one cannot hope for true understanding of the function of this or any other system without understanding the functions of its fundamental parts and their contribution to the function of the total system.

In grappling with the mass of data and the concepts that describe the roles of these fundamental units, it is easy to lose sight of the organization of these units into larger units, and the relationship of the larger units to one another and to the system as a whole.

Understanding the organization and relationship of structures is essential for a clinician caring for animals with neurological diseases because a clinician deals with the entire animal and with the entire nervous system. This requires a global approach that is based on an appreciation of how the functions of the various parts contribute to the function of the whole.

Normal functions must be known before abnormal functions can be recognized. Abnormal functions must be recognized because neurological diseases are manifested clinically almost entirely by dysfunction. It is uncommon for the clinical signs to include readily detectable anatomical changes. Therefore, a clinician must rely on signs of abnormal function to identify structures that are malfunctioning.

The nervous system lends itself readily to subdivision into major parts, each of which in turn is divisible into smaller parts. There are clinically detectable signs of normal and abnormal function for each of the major parts and their principal subdivisions. General divisions of the nervous system are:

1. Brain
2. Spinal cord
3. Peripheral nerves & muscles

The highest functional subdivision of the brain, and therefore the highest functional level of the nervous system, is the cerebrum. The cerebrum is the seat of consciousness and congnitive functions. It receives all sensory signals that reach consciousness, makes decisions on the most appropriate response, and initiates that response if one is needed.

In most cases the response the cerebrum initiates is a movement. This is called a *voluntary movement*. It is done by muscles innervated by lower motor neurons of the spinal cord or brain stem. The specific movement that is initiated is a phasic (on again, off again) event that may consist of nothing more than movement at one joint of an extremity. However, no matter how simple such movements may be, they require adjustments of other muscles so that opposing muscles relax or so that some joints are fixed while others are moved, or so that weight bearing on the legs is adjusted to accommodate shifts in the center of gravity.

The voluntary movement is initiated by the cerebral cortex and may be said to be an event of consciousness. The associated muscle activity is carried out subconsciously by successively lower levels of the nervous system: basal nuclei, mid brain, pons and medulla, cerebellum, spinal cord and brain stem, peripheral nerves and cranial nerves, and effector orgsa. The function of these lower levels is vital and without them voluntary movements become impossible.

In ourselves, we are conscious of the effects of these subconscious operations but we are not conscious of the complex neuronal transactions that produce them. These activities can be blocked normally only by very powerful cerebral cortical override and then only incompletely in most cases. Presumably animals also are not conscious of the functions of these subcortical systems and presumably they might have even less success in overriding them if they somehow chose to do so.

Abnormalities of movement and posture produce the most common neurological signs in animals. A very large proportion of these signs are caused by diseases that affect the subconscious events that occur in the many structures interposed between the cerebral cortex and the lower motor neurons. Because of the importance of these functions and the structures that produce them, recognizing signs of their dysfunction is an essential feature of that part of the general physical examination that we call the neurological examination.

Components of the nervous system

The following paragraphs attempt to provide an overview of the nervous system as a basis for the global approach and understanding that is required for dealing with neurological diseases. The overview simply provides a sketch of the overall plan to help form a conceptual framework. It does not provide many of the details that are essential to interpreting the results of a neurological examination.

The overview begins at the highest level and descends to the lowest. It is hoped that this will provide a basis for understanding the mechanisms involved in the production of the clinical signs that appear during the course of a neurological examination. The neurological examination actually is conducted in somewhat the reverse order; that is, by beginning with the peripheral nerves and the reflex arcs. This approach is used simply because the latter structures must be functioning before one can determine the function of each of the successively higher suprasegmental levels of organization. The truth of this last statement becomes evident if one considers attempting a neurological examination on an animal paralyzed by curare.

Cerebrum

The main portion of the brain, occupying the dorsal part of the cranial cavity; its two hemispheres united by the corpus callosum, form the largest part of the CNS.

The cerebrum receives all forms of sensory signals. The various types of stimuli can be classed in "sensory channels": olfactory, visual, auditory, vestibular, and somatosensory. All of these channels reach consciousness. Olfaction does so without passing through the thalamus but all of the other channels reach the cerebrum after signal processing in the thalamus.

A major function of the cerebral cortex is consciousness. Consciousness can be defined as awareness of sensory stimulation. It is said that the cerebrum is responsible for the content of consciousness while the reticular formation sets the level of consciousness. This is true but it should not be construed to diminish the importance of the cerebrum in consciousness. The cerebrum is the seat of consciousness and there can be no real consciousness without it. The ascending reticular activating system (ARAS) acts to adjust the level of activity of cerebral operations of consciousness but the ARAS does not itself enter into these operations.

The various sensory channels tend to reach specific areas of the cerebral cortex. The most important areas clinically are the visual areas in the occipital regions, the auditory areas in the temporal regions, and the somatosensory areas in the frontoparietal regions. Much of the remaining cortex is association cortex.

Information arriving in sensory channels is received and processed by the specific cortical areas and relayed to the association cortex. Cognition and decision making are functions of the association cortex.

If a decision is made to move, the association cortex is involved in planning the movement and initiating it. It brings about the movement by signaling the basal nuclei. The latter then process these signals and in turn signal the motor cortex (cruciate region) for execution of the movement (corticospinal tract), and the brain stem and cerebellum for initiation of the necessary associated muscle activity that shapes the body and limbs into a base for movement.

Clinical signs of cerebral cortex disease can include: disturbances of consciousness, paresis of voluntary movement, disturbances of all types of sensory function, and seizures.

Basal nuclei

The basal nuclei are specific interconnected groups of masses of gray substance deep in the cerebral hemispheres and in the rostral brain stem. Also referred to as basal ganglia. Includes caudate nucleus, lenticular nucleus,claustrum and amygdaloid nuclei

The basal nuclei are intimately related to movements initiated by the cerebral cortex. They are involved in the details of programming the movement, whereas the cortex as a command center merely plans and initiates the movement. To complete this activity the basal nuclei receive input from the association cortex and send signals to motor corfex and brain stem. The latter structures then signal the lower motor neurons via the corticospinal tracts and other descending pathways.

Some of the basal nuclei have an inhibitory effect on the pathways involved in voluntary movement. When these are affected by disease, involuntary movements can occur during rest and there is a tendency for dystonia (hypo- or hypertonia). These disorders are most severe in muscles that are most important in voluntary movement and fine manipulation (example, the prehensile muscles). Some basal nuclei disorders produce difficulty in the initiation of voluntary movement. Large unilateral basal nuclei lesions produce circling.

Cerebellum

The cerebellum acts to coordinate all of the subsystems that operate in locomotion and posture. In keeping with this, it receives afferents from the cerebral cortex, the basal nuc1ei, the vestibular system, the spina1 cord, and the reticular formation, and it has efferent connections with all of these systems. It is important to realize that the cerebellum has no direct connection with the lower motor neurons. Its powerful influence on posture and locomotion is brought about indirectly through its effects on the cerebral and brain stem structures that produce movement. It is important also to remember that the cerebellum does not initiate movements, but instead coordinates movements that are initiated elsewhere.

The clinical signs of cerebellar disease reflect its coordinating functions. Thus, the dysmetria of a cerebellar ataxia reflects loss of the cerebellar influence on phasic movements of the extremities. The disequilibrium reflects the failure of the cerebellum to coordinate the vestibular system with the brain stem and spinal cord systems that maintain equilibrium during the continuously shifting needs of voluntary movement. Note that neither of these signs of cerebellar disease is present at rest when there is no demand for coordination.

The cerebellum also participates in the coordination of eye positions and eye movements that occur in response to vestibular stimulation. The tonic deviations of the eyes and head and the positional nystagmus that occur in cerebellar disease reflect disturbances of these functions of the cerebellum.

Medulla and pons

Structures in the medulla and pons have major influences on the tone of antigravity muscles, thus serving to adjust weight bearing to compensate for shifts in the center of gravity. They receive afferents from the labyrinths and the spinal cord and they act on lower motor neurons through vestibulo- and reticulospinal tracts. These structures also have a very major influence on the maintenance of the visual axis parallel with the horizon and fixing the eyes on a target during movements of the head. Lesions affecting these systems cause disturbances of righting, abnormalities of muscle tone in the limbs, head tilt, and nystagmus.

Spinal cord

The spina1 cord contains neuronal mechanisms that can produce stepping movements (alternating flexion and extension of the joints of the limb). The supraspinal mechanisms described above end on these mechanisms and shape or mold them according to the needs of the movement by acting directly on primary afferents, interneurons, gamma efferents, or alpha efferents. Disorders of the descending pathways produce paralysis or paresis, and exaggerated reflexes. Disorders of the segmental cells produce depression of reflexes. These signs may be indistinguishable from those caused by lesions of the peripheral nervous system.

General characteristics of neurological disorders

Neurological disease can be acute or chronic, progressive or non-progressive. Neurological signs reflect only the location of the lesion(s), not the cause. Neurological diseases can sometimes cause intermittent signs (as in the case of epilepsy); some peripheral nerve or neuromuscular disease and some myopathies cause signs that fluctuate in severity from moment to moment or hour to hour or that vary in severity with exercise. Aside from these exceptions, the signs of neurological diseases tend to be continuous and fluctuate very little in severity.

The clinical signs of neurological disease are caused by dysfunction of the neurons. The neuronal dysfunction can be caused by direct effects of the disease on the neurons or by the effects of the disease on the supporting elements (glia) or blood vessels.

Neurological diseases may result from causes inside the nervous system or outside the nervous system. The causes include any of the things that cause diseases in other organ systems: degenerations, malformations, inflammation, trauma, metabolic disturbances, neoplasia, and nutritional, toxic, and vascular disorders.