ANCILLARY DIAGNOSTIC TESTS FOR NEUROLOGIC PATIENTS

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After determining that the patient has a neurologic disease, localizing the disease process, and forming a differential diagnosis, a diagnostic plan can be developed. This will include tests to ascertain the nature of the neurologic disease, but also include tests to evaluate any discrepancies in the physical examination. Some test should be performed on every neurologic patient while other tests must be selected based upon the location of the neurologic lesion or lesions. The former tests are called the minimum data base.

The Minimum Data Base:

A complete blood count (CBC) including a measure of chronic inflammation such as plasma fibrinogen should be performed on all patients. The presence of polycythemia or anemia, the presence of alterations in plasma proteins and the presence of inflammatory disease or possibility of disseminated intravascular coagulation (DIC) can be assessed, initially, through the CBC. The presence of reduced or elevated white blood cells (WBCs) may indicate infection with viral or bacterial pathogens. Myeloproliferative diseases may produce characteristic changes in the WBC. Increases in circulating nucleated red blood cells (RBCs) may indicate lead poisoning or the presence of hemangiosarcoma.

Serum chemistry profiles allow screening for metabolic and toxic conditions which could result in neurologic sequela. Since any disease which effects the body can affect the nervous system, whether directly or indirectly through metabolic intoxication, assessment of the bodies health through screening tests is important in understanding neurologic disease. As will be seen in seizure disorders, the changes reflected in the chemistry profile may help differentiate between an active seizure disease and epilepsy. To this end, the electrolytes (Na, K, Cl, Ca and PO 4 ) are important in muscle and nerve strength and reactivity. Assessments of BUN, cholesterol and albumin can help assess liver function. If all of these parameters are low, one should suspect a portosystemic shunt with diminished liver function. Elevations of cholesterol
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may help suggest endocrine abnormalities such as hypothyroidism or Cushing's disease. Elevated globulins might indicate autoimmune disease or, in the case of cats, the presence of feline infectious peritonitis.

Additional serum chemistries beyond routine screening tests may be indicated based upon the location of the lesion and the nature of the neurologic disease. For example, in seizures, all cases should also have serum cholinesterase levels run (to rule out organophosphate intoxication) and serum bile acid levels determined (to rule out liver dysfunction and as a base-line for possible future examines after anticonvulsant medications have been started). Dogs and cats with muscle pain or weakness may need additional serum muscle enzyme tests and determination of serum T4, T3 and TSH concentrations.

A urinalysis can help complete the assessment of the patient's health. Since many neurologic patients exhibit urinary retention or incontinence, this can be important in monitoring for urinary tract infection. Examination for ammonium biurate crystals can help establish diminished liver function, while the presence of calcium oxalate crystals might confirm ethylene glycol intoxication.

Appropriate parasite screens should be performed where indicated. Heartworm infection can result in neurologic and muscular diseases in endemic areas. Heavily parasitized young animals can become anemic or hypoglycemic as a result of the infestation, resulting in seizures or other neurologic conditions.

Routine radiographs of the chest and abdomen are indicated where disease is suspicioned based upon the physical examination. They may also be indicated in animals over 6-8 years of age, even in the absence of overt physical changes. When neoplasia is on the differential, then they are warranted. If the chest or abdomen are riddled with cancer, extensive workup for the concurrent neurologic disease may not be indicated. In addition to abdominal radiography, abdominal ultrasound examination may help determine the cause of the problem, even when abdominal radiographs do not show obvious lesions.

Other Physical Examinations


**Fundoscopic examination** may provide important information about the nervous system, since the retina and optic disc are the only parts of the nervous system which can be directly visualized. With CNS infection, active chorioretinitis might be seen. In the dog, this may mean fungal infection (aspergillosis or cryptococcoses), protozoal infection (toxoplasmosis or neosporidiosis) or canine distemper. In cats, it may lead to the diagnosis of cryptococcoses, toxoplasmosis or viral diseases (FeLV or FIP).

**Otoscopic examination** may help in diagnosing problems in the ears and is especially important in assessing animals with vestibular disease.

**Specific Neurologic Tests:**

Despite the many different disease processes which can assault the nervous system, there are a limited number of tests which can be used to help make the diagnosis. Many are indicated no matter what the nervous system disorder, while others are indicated for specific neurologic conditions. They include a CSF tap and analysis, electroencephalogram (EEG), electromyogram (EMG), brainstem auditory evoked response (BAER), skull or spinal radiographs, myelography and magnetic resonance imaging (MRI). Skillful use of these test will, however, allow for the diagnosis of the majority of neurologic conditions. Definitive diagnosis may be achieved by biopsy techniques, including muscle, nerve or brain biopsies.

The **CSF tap and analysis** is one of the most important tests which can be performed in assessing neurologic disease. It might be contraindicated in cases of recent or ongoing hemorrhage and in cases where the intracranial pressure is increased. However, in most cases, it provides direct information about the CNS with minimal risk, being less than that of anesthesia. Evaluation of CSF should include pressure (for cisternal taps), protein determination and cytology. Additional test on CSF might be beneficial in certain diseases, such as acetylcholinesterase levels and 2-D electrophoresis in degenerative myelopathy. In cases where infection is suspected, titers can also be helpful in diagnosing the cause. CSF can be collected from the cisterna magna or the lumbar cistern between L 5 and L 6. For most animals, a 22 ga spinal needle is best for achieving the tap, varying in length between 1.5 to 3.5 inches. Allowing the CSF to flow by gravity and collecting into a syringe as it drips from the hub of the needle, one cc of CSF can be collected for every 10 pounds of body weight. To run routine CSF analysis and titers, requires approximately 1.5 cc of CSF. Cytologic examination plays an important part of CSF analysis. Total counts can be useful, but we have found that close inspection of the "reactivity" of the cells on cytology may be more important than the total count. The best method to perform cytology is with the use of a cytocentrifuge. Since the cells deteriorate rapidly in CSF, cytology and cells counts must be performed within 20 minutes of
drawing the sample.

The **EEG** tests the outer 3 mm of the cerebral cortex and measures the electrical potentials between scalp electrodes. It can be used to test the forebrain and is an important diagnostic tool for diseases characterized by changes in behavior and seizures. To perform the EEG, the patient is anesthetized for any other neurologic tests which are being performed and, then, the scalp electrodes are inserted and connected to an EEG machine (a filtered, amplifier connected to a recording device). Once the connections are made, the recording is started and the anesthesia is turned off. The EEG is then recorded while the patient recovers from anesthesia. Performing the EEG in this manner induces some artifacts from the effects of anesthesia (however, these are minimized by using the same anesthesia in all patients and becoming familiar with the artifactual changes). On the other hand, it removes artifacts from EMG activity and movements, typical of awake EEG recordings. The normal EEG has fast, low amplitude activity (15-30 Hz and 5-15 µV, respectively). The presence of slow waves (alpha, delta and theta waves) with high amplitude indicates abnormality.

**Electromyographic** examination test the integrity of the lower motor unit. The needle EMG is performed by inserting an exploring electrode into the muscle to examine its intrinsic electrical activity. It is best performed under anesthesia, whereby nerve stimulation studies can also be performed. The presence of fibrillation potentials, fasciculation and bazaar high frequency discharges indicates increased irritability of the muscle membrane, occurring in disorders of the motor neuron, motor nerve, neuromuscular junction or muscle. Based upon the distribution of the EMG changes, the location and nature of the neurologic disorder may be indicated. Since muscle membrane irritability requires time to develop following denervation, the needle EMG may be normal for 5-7 days following acute injury of the motor unit.

Another important part of the EMG is determined by electrical stimulation of peripheral nerves. By stimulating at multiple sites along a motor nerve and recording the latency between the stimulation and the beginning of the compound action potential, the motor nerve conduction velocity can be determined. The distance between the stimulating electrodes at the two sites is divided by the difference between the latencies from the 2 sites to give the motor conduction velocity in meters per second (normal conduction is greater than 50 m/s). In addition to motor conduction velocity, repetitive nerve stimulation can be performed. Normally, the muscle can maintain activity at stimulation rates between 5-10 per second. In myasthenia gravis or sub-acute organophosphate intoxication, there is a decremental response to repetitive stimulation. The F wave is a low-amplitude wave seen several milliseconds following the compound action potential and is thought to be produced by antedromal spread of the stimulation pulse to the cell bodies of the nerve where it results in a secondary pulse traveling down the nerve to the muscle. The H wave is another low-amplitude response several milliseconds after the F wave and represents stimulation of the sensory fibers in the nerve and
subsequent reflexive stimulation of the motor neurons. Both the F wave and H wave may help examine the integrity of the central connections of the peripheral nerves. In addition to motor nerve conduction velocities, sensory nerve conduction can be measured. The sensory nerve is stimulated and a recording electrode placed proximally along the nerve records the passage of the impulse up the nerve. The distance to the recording electrode is divided by the latency of the impulse recording to determine the sensory conduction velocity.

The BAER records the electrical activity in the brainstem caused in response to auditory clicks in the ears. The BAER is not affected by sedation or anesthesia, so patients who are fractious can be sedated without affecting the results. The recording is made by placing a ground electrode in the untested ear, a reference electrode in the ear to be tested and a recording electrode over the vertex. The click is introduced in the ear to be tested and the electrical activity generated is averaged to reduce random noise. Generally, 5-7 middle-latency, waves are recorded, representing the transmission of auditory information through the vestibulocochlear nerve, the cochlear nucleus, the nucleus of the trapezoid body, the lemniscal nucleus and caudal colliculus, respectively. The BAER is used most frequently to test young animals for congenital deafness, but may also be used to test the integrity of the brainstem auditory system.

Neuroradiology and imaging include routine radiographs of the skull and spinal column. All neuro-imaging techniques are best performed under general anesthesia. Routine radiographs of the skull may reveal fractures, congenital defects, otitis media and interna and obvious neoplasia affecting the osseous structures of the skull. Routine spinal radiographs can help identify fractures, congenital malformations, evidence of degenerative disc disease, discospondylitis and neoplasia of the vertebra. However, many times the effects of the bony changes on routine radiographs do not provide sufficient information about the neural damage without the addition of special imaging techniques.

The most common of these techniques is myelography, performed by injecting contrast agent into the subarachnoid space through a spinal needle. Most of the time, the injection is made at the lumbar cistern and the contrast agent (Iohexol 180) is allowed to flow forward to fill the subarachnoid space to beyond the lesion. For diseases in the thoracolumbar region 0.33 cc/kg of body weight is used, while 0.45 cc/kg of body weight is used for cervical disease. It is best to use image-intensification to monitor the flow of the contrast agent and the dosage given adjusted to effect. Since most contrast agents are irritative, most neurologist believe they should not be performed in the face of obvious inflammation of the nervous system. In addition, this irritation can result in seizures upon recovery from anesthesia, another reason not to inject more than necessary to fill the subarachnoid space to the level of C1. Giving methylprednisolone immediately following the contrast injection can reduce the incidence of post-myelographic seizure, probably due to helping to maintain intercellular glucose concentrations.
A number of other special imaging techniques have been applied to neuro-imaging including computer assisted tomography (CAT) scans, radioisotopic brain scans, cerebral angiography and ventriculography. Of these, only the MRI provides anatomic detail when examining the nervous system. All portions of the CNS can be imaged by MRI. The MRI provides evidence of increased tissue density and fluid accumulation, demonstrates anatomic shifts in CNS structures, and (coupled with contrast studies) demonstrates breaks in the blood-brain barrier. For CNS neoplasia and for lumbosacral stenosis, MRI is the imaging method of choice.

**Diagnostic Plans:**

Although the neurologic tests above can help diagnose neurologic disease, not all are indicated for all conditions. For simplicity, the problems of the nervous system can be broken into 1) diseases above the foramen magnum (diseases with head signs), 2) diseases of the spinal column (diseases of quadriparesis or paraparesis) and 3) diseases of the peripheral nerves and muscle.

For diseases of the head, the diagnostic plan includes:

1. 1) minimum data base,
2. 2) fundoscopic or otoscopic examination,
3. 3) CSF tap and analysis,
4. 4) skull radiographs,
5. 5) EEG or BAER (EMG if cranial neuropathy), and
6. 6) MRI.

For diseases of the spine, the diagnostic plan includes:

1. 1) minimum data base,
2. 2) CSF tap and analysis,
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3. 3) spinal radiographs,
4. 4) myelography,
5. 5) EMG, and
6. 6) MRI.

For diseases of the peripheral nerves or muscle, the diagnostic plan includes:

1.
1. 1) minimum data base,
2. 2) EMG,
3. 3) special muscle enzymes, and

4) muscle and nerve biopsy.