

Save a Life

Neuro-Optometry Primer: The Brain

By Mario Gutierrez, O.D., F.A.A.O.

Introduction

Three years ago, I noticed my then-17-year-old son, J. Taylor Gutierrez, was having difficulty running. I wondered whether the problem was neurological—so I dusted off some of my old neurology textbooks to refresh myself on neuro-screenings. To my dismay, he failed, and he has since been evaluated by his primary care physician and specialists. While we are waiting still for a definitive diagnosis, I have busied myself with reading the clinical literature on neuro-optometry. The more I learned, the more I realized how easy it would be to incorporate a neurological screening into my optometric practice. That effort gave rise to this primer, developed to encourage more optometrists to add aspects of neuro-optometry into their practices.

This primer is intended to accomplish the following:

- Review the basics of neuroanatomy
- Describe the clinical screenings that would be appropriate and easy to incorporate into an optometric practice
- Help you explain to patients the critical connections between the eyes and the brain

Throughout the primer, you will find highlighted clinical pearls and definitions. The final page of the publication incorporates a neuro-optometric screening guide that can be used in your office.

What's the benefit? There are multiple advantages, as I've learned in my own practice. First of all, these screenings take little additional time but have significant rewards in terms of patient education and awareness. Because neuro-optometry screening is more hands-on than other services we offer, be prepared to explain to patients what you're doing and why. Patients will be intrigued. Many thank me for the thorough exam, saying they've learned something new. The ultimate benefit, however, would be the ability to detect a neurological problem. Every optometrist who has made a potentially life-saving or life-changing diagnosis knows how gratifying that can be—even when it's difficult to share the news with the patient. There can be nothing more professionally rewarding than making an enormous difference in a patient's life.

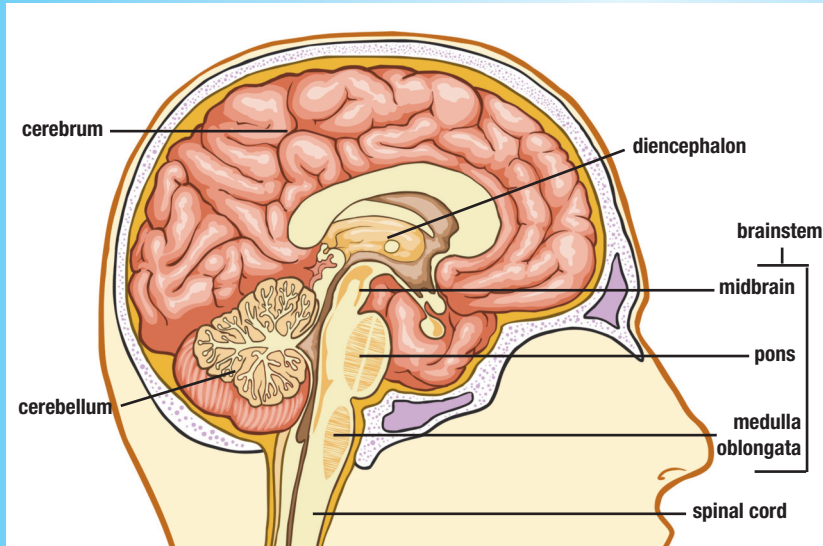
I dedicate this primer to my son and my optometric colleagues. I encourage you to consider adding neuro-optometric screening in your practices.

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The Basics of Neuroanatomy

To begin our review of the central nervous system (CNS), let's start with the brainstem, which has multiple functions. This stalk-like structure functions as a highway of nerve fibers sending information from the cerebrum, cerebellum and other structures to the spinal cord and vice versa. Any brainstem lesion typically results in significant neurological deficits as there is so much activity in such a tight space. Think of the cranial nerves as spinal



How to Describe Anatomical Orientation

rostral: towards the top. Think of a pretty rooster head to help you remember rostral.

caudal: towards the bottom. Think of "cow tail" to help remember caudal.

dorsal: along the back. Think of a shark's dorsal fin.

ventral: along the belly. Imagine a skeleton lying face down with the rib cage having vents between the ribs.

nerve fibers inside the skull. The brainstem is generally divided up into the midbrain, pons and medulla. The most caudal of the brainstem structures (see diagram) is the medulla.

The medulla contains CN 9, 10, 11 and 12. Rostral to it is the pons. The pons contains CN 5, 6, 7 and 8. Dorsal to the pons is the cerebellum. Rostral to the pons is the midbrain, which contains CN 3 and 4. CN 1 and 2 are a little rostral to the midbrain. To help visualize the orientation of the cranial nerves, think of the 12 cranial nerves divided evenly among the three brainstem structures. CN 1-4 lie in or near the midbrain; CN 5-9 are in the pons, and CN 9-12 are in the medulla.

CLINICAL PEARL. Keep in mind the concept of the "neighborhood effect." Neurological problems stemming from lesions can affect neighboring areas. For example, a large lesion that affects one cranial nerve might affect an adjacent cranial nerve nucleus, thereby creating multiple symptoms, which can help us localize the problem.

Here are the cranial nerves and their basic functions. Some cranial nerves are purely motor in nature, some are sensory and some are mixed—both motor and sensory. Some of the cranial nerves also are involved in autonomic innervation.

CN 1: sensory—smell

CN 2: sensory—vision

CN 3: motor—moves EOM (except SO and LR) and upper lids, pupil constriction and accommodation

CN 4: motor—superior oblique (SO₄—remember this from chemistry—sulfate ion)

CN 5: mixed—chewing and head/face sensory

CN 6: motor—lateral rectus (LR6)

CN 7: mixed—facial muscles, salivation, lacrimal gland and taste

CN 8: sensory—balance and hearing

CN 9: mixed—taste posterior tongue, swallowing, monitors carotid body

CN 10: mixed—swallowing, voice, elevates palate, communication with thorax area and abdomen viscera



CN 11: motor—shoulder lift/shrug and head turn

CN 12: motor—tongue movement

Remember this mnemonic device some professors in optometry school used to try to get us to remember the cranial nerve names and their order? “Oh, oh, oh to touch and feel a genuine...” helped us remember: olfactory nerve, optic nerve, oculomotor nerve, trochlear, trigeminal nerve, abducens, facial, auditory.... Don't worry about remembering that anymore. **What is important to learn is which nerves are sensory, motor and mixed, and to learn their basic functions.** The sensory nerves are associated with some of our sensory anatomy: nose (CN 1), eyes (CN 2) and ears (CN 8). Optometrists are aware of most of the motor nerves because of our familiarity with the extraocular muscles (CN 3, 4, 6), to which can be added the last two cranial nerves, CN 11 and 12. The rest are mixed—CN 5, 7, 9 and 10.

Cranial Nerve Testing

With a little practice, you will be able to perform these basic screenings of cranial nerves quickly.

- CN 1.** Have patients smell two different items unilaterally (coffee, cinnamon or other nonirritating items). Make sure they cover one nostril while performing this test. You can use a medication canister to store the items. The olfactory nerves are actually very small and synapse with the olfactory bulb, which is part of the CNS.
- CN 2.** These tests include VA, BVA, confrontation fields, automated visual fields screening, color vision (Ishihara or HRR), Amsler Grid and pupils (APD). Don't forget to examine the optic nerve with direct ophthalmoscope or SLE for signs such as any pallor, edema, hemorrhage, cupping and retinal nerve fiber loss.
- CN 3.** Examine pupils (efferent **or away from CNS**), EOM testing (superior rectus, inferior rectus, medial rectus and inferior oblique) and the levator. (Look for ptosis—but remember that ptosis can be associated with other etiologies.)

Conduct pupil testing by performing direct, consensual, swinging flashlight test for an APD, and for completeness, look at the patient's accommodative pupil reflex.

The most feared cause of isolated CN 3 palsy in adults is a posterior communicating artery (PCA) aneurysm. For an isolated acquired partial or complete third nerve palsy with pupil involvement, a PCA aneurysm should be ruled out emergently.

CLINICAL PEARL: With an afferent pupillary defect, the eye with the problem will show a greater consensual pupillary response than a direct response. Therefore, with direct stimulation, that particular pupil will respond less than when the light is shined in the opposite pupil. If there is an APD, then the lesion is likely anterior to the chiasm. (An optic tract lesion can also lead to APD in the contralateral eye because more fibers **"cross over"**.)

CLINICAL PEARL: Checking the consensual response in dark eyes can be difficult. Try this technique: using your retinoscope, look at the eye for a consensual pupil response while shining your light on the other eye. You can also do this with a direct ophthalmoscope, by dialing in either +1 or +2, then observing the red reflex in one pupil, while shining the light on the other eye.

CLINICAL PEARL: If patients have a complete third nerve palsy, the eye rests in a “down and out” position. Remember this by thinking of this eye being out of luck—being down and out. A partial third nerve palsy is not in any better luck. In general, all acute third nerve palsy patients need to have further workup including neuroimaging.

CN 4. Controls the superior oblique muscle.

CLINICAL PEARL: In a fourth nerve palsy, patients may tilt their head to the opposite side of the eye with the problem. For example, patients with a fourth nerve palsy to the left eye may walk with their head tilted to the right. The involved eye is higher when patients look straight ahead.

CN 5. Double stimulate all three divisions (ophthalmic, maxillary and mandibular). Use a cotton tip applicator and stimulate both sides simultaneously—the forehead above the eyebrow (ophthalmic), then the cheeks (maxillary), and then the mandible (mandibular). Do this with both the cotton tip side, and then repeat with the wooden tip. I have found it helpful to break off some of the wooden stick to create a sharper edge to help the patient differentiate the cotton tip area (dull) from the sharp end.

Corneal reflex testing may be useful to help confirm a fifth or seventh nerve problem. Touch the tip of the cornea with a cotton wisp; the fifth nerve carries the information to the brain. It then signals the eyelids to close via the seventh nerve.

To test the motor function of the fifth nerve, place your hands on the patients' masseter muscle and ask them to clench their teeth. Look for weakness or loss of muscle mass.

CN 6. Controls the lateral rectus muscle.

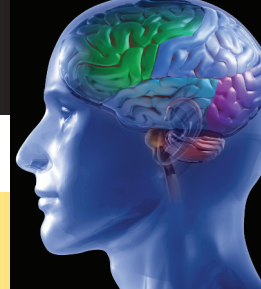
CLINICAL PEARL: The sixth nerve is very susceptible to increased intracranial pressure. This is why patients with papilledema often will complain of diplopia secondary to sixth nerve involvement.

CN 7. Ask patients to smile. Is it even from side to side? Ask patients to puff their cheeks against resistance. To check the obicularis strength, have patients close their eyes. Then you try to open them manually. Also, ask patients to wrinkle their forehead.

CLINICAL PEARL: In Bell's Palsy, there is facial paralysis on an entire side of the face. The cause is an injury somewhere between the pons and the face. In cerebral lesions (or on the pathway to the seventh nerve nucleus) such as stroke, the patient will be able to wrinkle his or her forehead! Always ask patients if they have had recently received Botox injections.

CN 8. Rub your fingers together behind the patients' ear. Does the patient hear the noise? Equally? To evaluate the vestibulo-ocular reflex, have patients look at a distant object and move their head horizontally and vertically. Eyes should stay fixated on the target when the head is moved.

CLINICAL PEARL: Vertigo must be differentiated from dizziness. Vertigo is a spinning sensation and can be associated with vestibular disease. Patients may say they have vertigo, but they are really describing dizziness (lightheadedness, unsteadiness, etc.). Patients with vertigo should be seen by their PCP as soon as possible, especially if they also show other neurological signs, such as diplopia, weakness and poor coordination.



CLINICAL PEARL: If the patient fails the CN 8 hearing test, it might be due to a conductive disorder. Differentiate from a sensory disorder by asking the patient to hum. The abnormal ear that detects a louder hum is the ear with the conductive defect. If there is a sensory defect, then the hum is louder in the normal ear.

CN 9 & 10. Both of these nerves are tested at the same time since clinically their functions are very similar. Using a tongue depressor, ask patients to say “ahh.” Observe the uvula for any sideways deviation. Palate should rise symmetrically with little nasal air.

Also test the gag reflex. Use a tongue depressor to hold down the tongue, then gently touch the posterior pharyngeal wall with a cotton tip applicator (or you can use the tongue depressor gently). This test is generally only done in suspected brainstem disease or in a patient with swallowing difficulties.

CN 11. Push down bilaterally as patients shrug their shoulders. Have them turn to left, look at and palpate the right side sternocleidomastoid muscle. Create resistance from your hand.

CN 12. Ask patients to stick out their tongue. It should be straight out. Also, have them put tongue in cheek against resistance bilaterally.

Now let us go into more detail on some of the wiring associated with cranial nerves and their function. Remember that the cranial nerve nuclei are not exclusive to a particular nerve or brainstem structure. For example, the sensory nucleus of CN 5 is long and extends from the midbrain to the spinal chord. There are several cranial nerves that borrow CN 5’s sensory nucleus for its own use, such as the sensory component of CN 7, 9 and 10. This is an example of how a structure or function can be innervated and influenced by multiple cranial nerves (such as taste, which is primarily controlled by both CN 7 and 9). There are also some nerves with multiple nuclei, such as CN 10. This is how a cranial nerve can have multiple functions.

Put into Practice

Perform a quick cranial nerve screening on a family member or staff. Visualizing the anatomy that you are testing helps you remember the specific tests and procedures. The more you perform it, the more efficient and effective you become. My experience in doing these tests on patients is that they are very impressed with the hands-on thoroughness that these tests add to their medical office visit.

CLINICAL PEARL: Because of its compactness, and with numerous nuclei that may be associated with various cranial nerves (and with cranial nerves with more than one nucleus), a brainstem lesion usually will be associated with multiple signs and symptoms.

The motor-cranial nerves usually do not do what they do without some input from the boss—the cerebrum. Sensory-cranial nerves also need the cerebrum to interpret their findings. Different parts of the cerebrum are allocated to controlling motor nuclei, and different parts of the cerebrum are responsible for interpreting sensory input from nuclei. Still different parts of the CNS are involved in the autonomic functions of the cranial nerve.

If there is a neurological problem associated with a particular cranial nerve, the etiology could be a lesion somewhere along the wiring between the cerebrum and nuclei in the brainstem. This is called a **supranuclear** lesion, as it is above the nucleus. The problem could be within the nuclei (**intranuclear**), somewhere in the wiring between nuclei (**internuclear**), or somewhere along the path from the actual cranial nerve to its endpoint.

CLINICAL PEARL: Most optometrists test the cranial nerves (and all the wiring/nuclei/higher-order components associated with that nerve) basically in a pass-or-fail fashion. Yet there are multiple possibilities as to why a particular cranial nerve does not pass this screening.

An important structure on top of the brainstem is the thalamus. Imagine two egg-shaped structures side by side on top of the midbrain. They are larger than the midbrain platform and overhang it rostrally. The thalamus is a very important relay structure to send sensory and motor information to the brain. The lateral geniculate body (LGN) is located in the lateral dorsal aspect of the thalamus. It receives the majority of the nerve fibers from the optic tracts, and then sends this information via the optic radiations to the primary visual cortex in the occipital lobe.

The Cerebellum

The cerebellum plays a role in the control of eye movements. Optometrists need to be able to make a basic and quick assessment of its function in certain patients.

The cerebellum lies dorsal to the pons and caudal to the occipital lobe. The cerebellum plays a major role in motor control and posture. It helps to integrate feedback to the body's motor systems. This is why cerebellar problems typically do not cause paralysis, but rather they manifest as jerky movements and difficulty with posture and equilibrium. Cerebellar lesions often result in ataxia (irregular and poorly coordinated movement). The cerebellum has connections to the vestibular system in the brainstem (with links to the extraocular muscle nuclei). Conceptually divide the cerebellum into the midline vermis area and two cerebellar hemispheres. The tests you will perform have a tendency to evaluate either the midline area or the cerebellar hemispheres, and thus they can help you identify the location of a cerebellar lesion.

CLINICAL PEARL: Unlike most cerebrum lesions, cerebellar lesions tend to manifest themselves on the same side of the lesion. Patients have a tendency to fall to the same side as the lesion. Cerebellar problems can lead to saccades overshooting or undershooting their targets. In addition, jerky nystagmus can be seen often in these patients.

The following tests **do not exclusively** test the cerebellum. They involve evaluating patients' coordination, which is a major responsibility of the cerebellum.

Cerebellum Midline Tests:

Station: Ask patients to stand still. Next, ask them to hop on one foot while patting their knee. Then repeat this with the other leg. Can they maintain balance?

Walking: Evaluate patients' gait as they walk back and forth a couple of times.

Tandem Gait: Have patients walk heel-to-foot in a straight line (like a sobriety test).

Cerebrocerebellum Tests:

(to evaluate the cerebrum's connection to the cerebellar hemispheres)

Finger to Nose: Ask patients to close their eyes while holding arms out (like an airplane), then ask them to touch their nose with the index finger. Next, ask patients, with eyes open, to touch their nose and then touch your finger. Move your finger forward and back and side to side, and ask patients to touch your finger at these different locations. Repeat using the other hand. You can do similar testing asking patients to touch your finger with their toe.

Heel to Shin: While patients are sitting or lying down, ask them to place their heel on the opposite knee and slide it down to the ankle and back. Repeat the test with other leg.

Rapid Alternating Movements: Ask patients to tap their foot rapidly against your hands. Repeat on the other side. Test the ability to touch the thumb rapidly with the forefinger multiple times. Repeat this with each individual finger



to the thumb, and repeat the test with the other hand. Also, test the ability to twist each wrist rapidly. Finally, ask patients to pat their thigh rapidly with each hand, palm down and palm up.

Rebound: Ask patients to close their eyes and stretch out their arms in front of their body. Let patients know that you will tap on their arms while they try to keep them at the same place. You want to see if their arms rebound.

Check Reflex: Have patients flex their elbow and make a fist as you pull forearms towards you (as patients resist), and then let go. Patient should be able to keep from hitting themselves with their fist.

As optometrists, do we really need to worry about the cerebellum? Yes, because there is definite wiring from the cerebellum that is associated with ocular muscle coordination and movement. Therefore, we should be familiar with all these tests in order to perform them in patients with suspected cerebellum problems.

Diencephalon

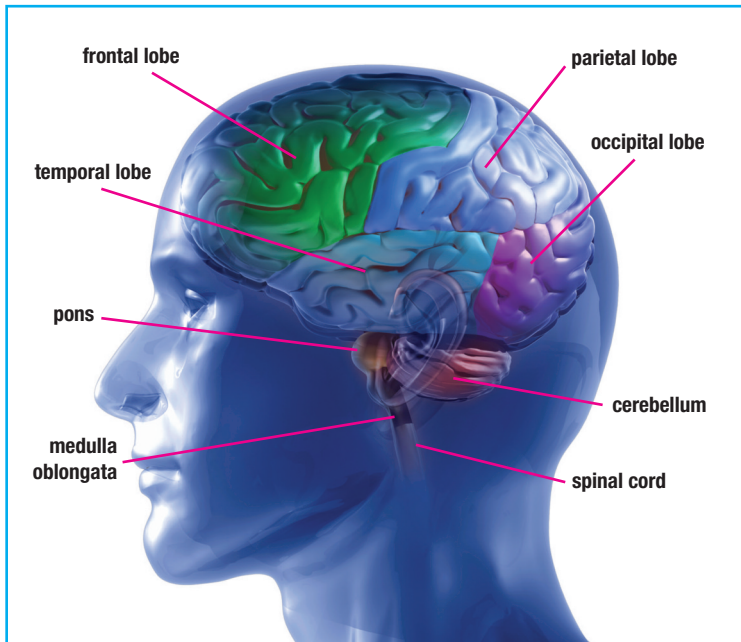
The diencephalon is comprised of the thalamus, hypothalamus, epithalamus (includes pineal gland) and subthalamus. The hypothalamus, which is about the size of an almond, is located slightly inferior to the thalamus. Structurally, the hypothalamus is attached to the pituitary gland by the pituitary stalk. The hypothalamus communicates with the pituitary gland via hormones, as opposed to nerves. The pituitary stalk is located dorsal to the optic chiasm, and the pituitary gland is inferior to the chiasm.

CLINICAL PEARL: Pituitary tumors are the most likely lesions associated with chiasmal compression. Pituitary tumors can be responsible for field defects that are primarily bitemporal and tend to be asymmetric. Since the pituitary is growing from below the optic chiasm, it will press on the inferior nerve fibers, thus potentially resulting in superior field defects.

Basal Ganglia

The basal ganglia are a cluster of nuclei located temporally to the thalamus. Similar to cerebellum, they modulate the motor system without direct motor output. They also are involved in learning, cognition and emotions. The basal ganglia receive information from various areas of the CNS and then proceed to fine-tune this information. They subsequently send this information to the thalamus, which then forwards it to particular areas of the cerebrum. The basal ganglia function in conjunction with the cerebellum to coordinate voluntary movement. Basal ganglia diseases and lesions tend to produce uncontrolled twist and jerk-like movements, and they can be also produce hyperkinetic or hypokinetic movements. An example of a hypokinetic, basal ganglia-degenerative disease is Parkinson's disease. With Parkinson's, you will observe rigid and slow shuffling movements that are difficult to initiate, in addition to the resting tremor we associate with this disorder. Other basal ganglia diseases or associated diseases include Huntington's chorea, ADHD, obsessive-compulsive disorder, Tourette's disorder and Wilson's disease. (Optometrists can help detect Wilson's disease by observing a golden-brown copper ring in Descemet's membrane in the peripheral cornea or, less frequently, a sunflower cataract.)

CLINICAL PEARL: Test basal ganglia by observing patients' motor behavior, including EOM movements. Since the basal ganglia contribute in coordinating motor movements, there is no clinical testing that can be performed to isolate and test the basal ganglia specifically. Remember that basal ganglia diseases can be associated with patients making unexpected, unintentional motor movements.

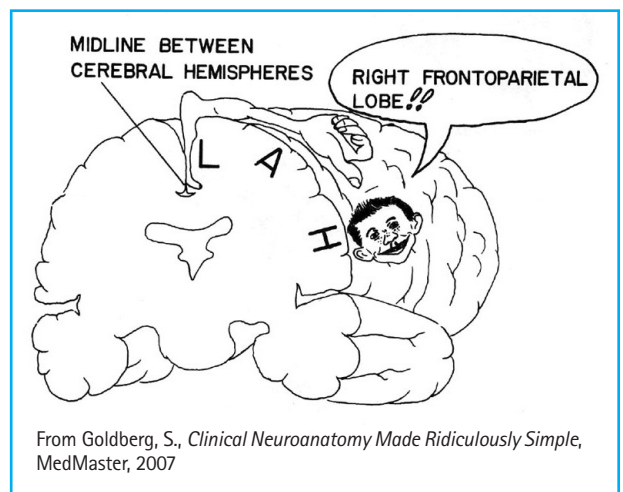


Cerebrum

Now let's turn our attention to the "boss"—the cerebrum. The cerebrum generally is divided into four different lobes (see diagram). The cerebral cortex is the gray matter layer that is the exterior cover of the cerebrum. The cerebral cortex is composed primarily of cell bodies that are wired to communicate with each other. Underneath the gray matter is the white matter that is made up of myelinated nerve fibers that send information farther. The folded bumps in the cerebral cortex are called gyri, and each groove between gyri is called a sulcus. (All these folds and sulci add to the surface area of the cerebral cortex to give us more processing gray matter!) A deep sulcus is referred to as a fissure. A lobe is a section of cerebrum.

The dominant cerebral hemisphere controls dominant hand and leg movement and much of language. If you are right-handed, then your left cerebral hemisphere would be considered dominant.

Frontal lobe. Functionally, the frontal lobe is separated into two major areas. The anterior portion is important in higher mental functions and in the determination of personality. A portion of this area (in the dominant frontal lobe) that is responsible for expressive language is called Broca's area. The posterior part of the frontal lobe is important for motor function. The frontal lobe and parietal lobe are separated by the central sulcus (also called the central sulcus of Rolando). Looking at a coronal section of the brain, Stephen Goldberg, M.D., in his book, *Clinical Neuroanatomy Made Ridiculously Simple*, describes an easy way to remember the frontal lobe's topographical representation to a particular part of the body. Imagine an upside-down man named "HAL," whose legs are in the midline and head adjacent to the temporal lobe. HAL is an acronym for head, arms and legs. Therefore, a lesion near the "A" area of the posterior frontal lobe would affect a patient's ability to move his or her arms.



From Goldberg, S., *Clinical Neuroanatomy Made Ridiculously Simple*, MedMaster, 2007

Parietal lobes. The parietal lobes primarily are involved with sensory responsibilities, such as pressure and touch. They are also involved in visual spatial processing (nondominant hemisphere) and praxis (dominant hemisphere). Praxis is the ability to form an idea that is needed to perform a motor task. The motor task is then actually initiated by the frontal lobe. Basically, the concept of HAL applies to the sensory topography similar to the frontal lobe's motor-function topography. Therefore, a lesion near the anterior parietal lobe's midline would affect sensory function of the patient's legs.

CLINICAL PEARL: Remember HAL'S orientation to help isolate the location of lesions or strokes. Remember the right side of the cerebrum controls the motor function of the left side of the body, and vice versa.



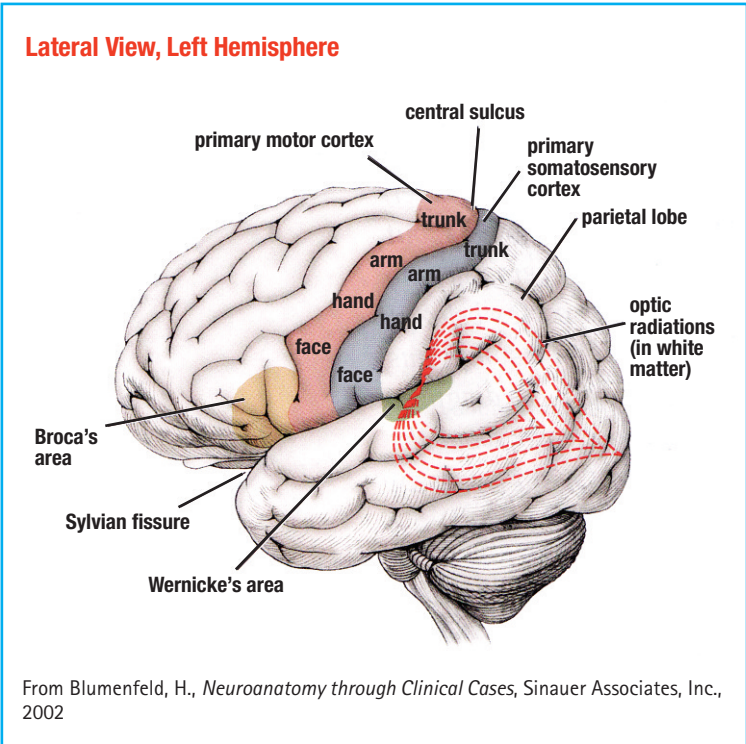
Temporal lobes. The temporal lobes have a number of functions and responsibilities. The superior part of the temporal lobe contains the auditory complex. Speech processing (language comprehension) is located on the left temporal lobe for most right-handed people (this is also the case for approximately 75 percent of left-handed people). This area is called Wernicke's area. This lobe is also involved with sense of smell. The temporal lobes are separated from the frontal lobe by the lateral fissure (also called the Sylvian fissure).

CLINICAL PEARL: The inferior optical radiations loop through the temporal lobe (Meyer's loop). Therefore, a lesion in the temporal lobe could cause a superior visual field defect, better known as the "pie-in-the-sky" defect.

Occipital lobe/lobus occipitalis. The occipital lobes are primarily responsible for vision, including visual recognition. The occipital lobe and parietal lobe are separated by the parieto-occipital sulcus.

Why is it important to know which is the dominant hemisphere in the particular lobes? If you know a patient has a problem with a particular higher-order mental function (that is associated with a particular lobe, i.e., speech-temporal lobe), you possibly can isolate not only which lobe might be affected, but also the hemisphere. To review, the dominant hemisphere is involved with the frontal lobe (expressive language), temporal lobe (receptive language) and parietal lobe (praxis). The non-dominant hemisphere is involved with visual spatial processing in the parietal lobe.

I recommend using Dr. Goldberg's "FOGS" method of evaluating a patient's mental status to help screen the cerebrum's higher-order, thinking functions. FOGS stands for family story, orientation, general information and spelling. Here is the testing procedure.



From Blumenfeld, H., *Neuroanatomy through Clinical Cases*, Sinauer Associates, Inc., 2002

1. Family story: ask a family member if there has been any memory loss. If so, has it been a rapid loss?

CLINICAL PEARL: Short-term memory is lost before long-term memory in brain damage.

2. Orientation: ask the patient the current day, month and year.
3. General information: ask the patient to name the president and vice president of the country.
4. Spelling: ask the patient to spell the word "world" or any other common five-letter words. Then ask the patient to spell that same word backwards. Also mention three objects (i.e., pen, glass and car). A few minutes later, ask the patient to repeat the objects.

Blood Supply

Knowing the brain's arterial system can help identify where a lesion or stroke is located.

Start with the Circle of Willis. Imagine the Circle of Willis looking like home plate on a baseball field (see diagram) with the pointy part being caudal near the midbrain, and the rostral part ending near the base of the frontal lobe. The Circle of Willis is filled by the basilar artery coming from the umpire's position, and two internal carotid arteries (imagine a baseball player's legs straddling home plate, with his legs being the carotids). A pair of arteries leaves the anterior portion towards the pitcher's mound (anterior cerebral arteries), a pair of arteries leaves medially towards the dugouts (middle cerebral arteries) and a pair leaves the back side (on either side of the point) towards the backstop (posterior cerebral arteries). The internal carotid artery connects with the posterior cerebral artery (near the point) via the posterior communication artery, and it connects with the anterior cerebral arteries via the anterior communicating artery.

Proceeding caudally, there are artery branches off the basilar artery that serve the brainstem and cerebellum. At the level of the caudal pons, the basilar artery divides into two vertebral arteries that then connect to subclavian arteries, which ultimately connect to the aorta.

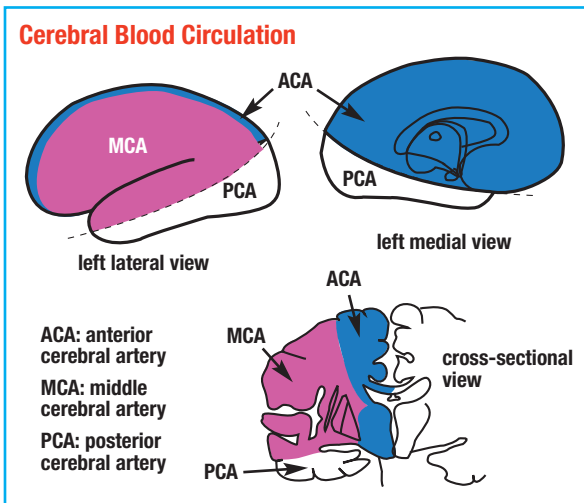
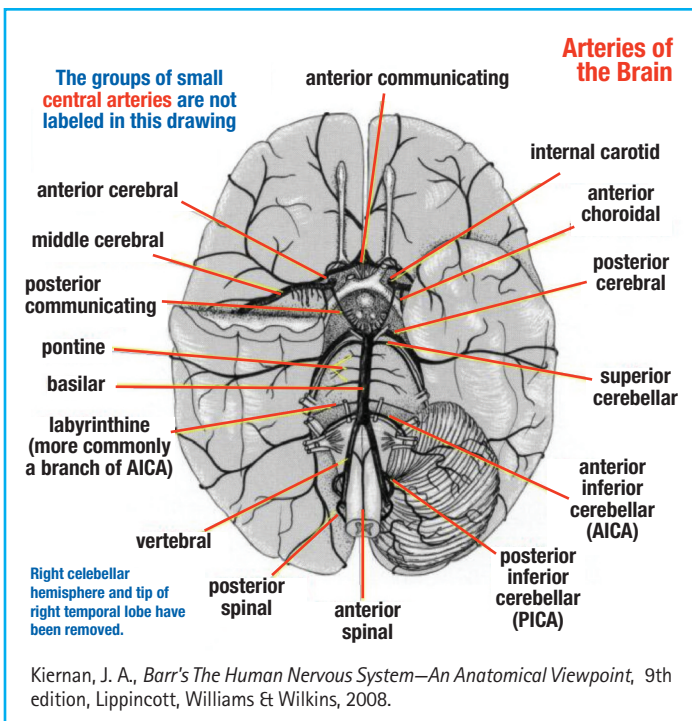
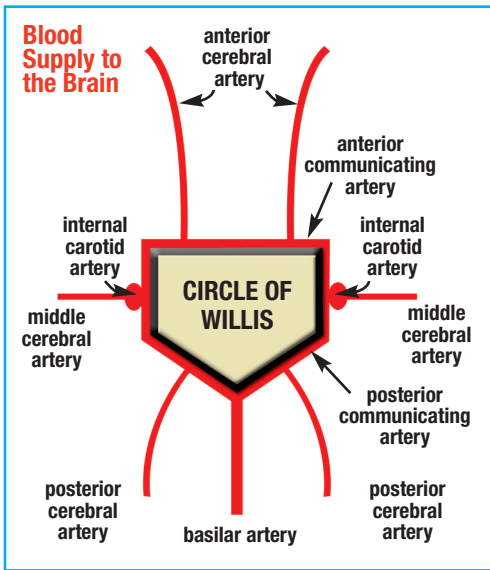
In the diagrams, look at the various areas of distribution for which each artery is responsible.

If there's a problem with a patient's left anterior cerebral blood flow, then the patient probably will have some difficulty with the right lower extremities.

Meninges

The brain and central nervous system are surrounded by and protected by the meninges—dura mater, arachnoid mater and the pia mater. The dura is closest to and attached to the skull (bone), and it has a pretty cool Latin translation: "hard mother." There are important venous channels called sinuses that are contained within the dura. These dural venous sinuses are channels that eventually drain blood to the internal jugular veins. The arachnoid is the middle meningeal layer, and it gets its name by being "spider web-like." The arachnoid has granulations that project into the sinuses and veins so that circulated cerebral spinal fluid can be transferred to the bloodstream. The pia is a very thin membrane that adheres to the brain's surface. It is easy to remember the order of the meninges layers because their job is to protect or PAD (pia, arachnoid, dura) the brain.

There are three clinically significant spaces contained between the different meninges. The first is the epidural space, which is located between the dura and the skull/bone. If there is a closed head injury,





especially in adults, blood might collect in this space. The second or subdural space is located between the dura and arachnoid. This is a space that potentially can be filled by blood, especially in a closed head injury to a child. Accumulated blood in this area can push on the lower layers and cause subsequent pressure on the brain. The subarachnoid space is the third space. It lies between the arachnoid and pia mater and is filled with flowing cerebrospinal fluid.

Check for meningeal irritation by flexing the patient's head. If the patient complains of significant pain around the back of the neck, suspect meningeal irritation. The patient with meningitis or a subarachnoid hemorrhage may also complain of a headache near the back of the neck with associated neck stiffness.

Ventricles/Cerebral Spinal Fluid

The brain has four fluid-filled ventricles. The ventricles contain structures called the choroidal plexus that are responsible for producing cerebral spinal fluid (CSF). The CSF flows from the pair of lateral ventricles that wrap around the dorsal basal ganglia, then continue down to the third ventricle located near the thalamus. The CSF continues to the fourth ventricle, which is sandwiched between the dorsal pons and medulla on one side and the cerebellum on the other. From here, it leaves via several foramen into the subarachnoid space. There is approximately 150 ml of CSF in the central nervous system at one time, and about 500 ml/day is produced. Eventually, the produced CSF will drain into the dural sinuses through very small openings called arachnoid villi.

CLINICAL PEARL: The subarachnoid space around the optic nerve usually does not have CSF in it, but with elevated intracranial pressure, CSF fills the space. This squeezes the optic nerve and ultimately can result in papilledema. The squeezing stops the axoplasmic flow that results in an accumulation of material at the lamina cribrosa and swollen axons. This results in the swelling of the disc we see in papilledema.

Part of Medical Eye Care

Should you perform this rapid neurological assessment as part of your vision examination? Unless there is concern that the patient is in immediate peril, schedule the patient for a subsequent medical office visit in the near future, probably early the next day. If the patient was originally scheduled for a well-vision exam, and the case history indicates a need for a neuro-optometric screening during the original encounter, then inform the patient that you will be modifying the exam procedures along with the billing and coding to reflect a medical examination (and complete the requirements of the medical exam). However, like the vast majority of caring optometrists, if the need presents itself, most of us will perform the neuro-optometric exam, regardless of the reimbursement.

Incorporating aspects of a neuro-optometric screening in your medical eye exam could be a very important component in helping to differentiate it from a routine well-vision exam. I think it is good optometric medical care to have the patient complete a comprehensive review of systems form on the medical follow-up visit (if this was not done at the time of their most recent well-vision exam), and perform at least a visual field screening on all patients undergoing an optometric neurological assessment.

You will find that it is easy and rewarding to incorporate these procedures into your daily practice. Your patients will be impressed with your thoroughness, and you will be perceived as "more medical." Most of all, how good are you going to feel when your neuro screening detects a neurological problem, and you are the one that made the difference in a patient's life?

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Neuro-Optometric Screening Guide

Mental Screening: FOGS—family, orientation, general information and spelling

1. Ask family members whether they have concerns about the patient.
2. Ask patient: What is the exact time (month/date/year)?
3. Ask patient to say dog, fish and car. Ask the patient to repeat these words in five minutes.
4. Ask patient: Who is our president and vice president?
5. Ask patient to spell "world" forwards and backwards. (See page 9.)

Cerebellar Function:

1. Finger-to-nose test
2. Heel-to-shin test
3. Station
3. Rapid alternating movements: foot to your hand, thumb to their fingers (all individually), pat hand to his/her thigh (palm up and palm down), and rapidly twist his/her wrists. (See pages 6-7.)
4. Tandem gait.

Cranial Nerves:

1. CN 1—Test for unilateral smell of two different substances.
2. CN 2, 3, 4, 6 should be on your exam form already. Don't forget to do confrontation fields or visual field screening.
3. CN 5—Perform double simultaneous stimulation of both sides of face-temple area, cheek and mandible. Test masseter by having patient clench teeth.
4. CN 7—Have patient smile and puff cheeks against resistance; look for asymmetry. Ask about problems with sense of taste.
5. CN 8—Does patient hear fingertips rubbing together? Test vestibulo-ocular reflex.
6. CN 9 & 10—Use tongue depressor, and ask patient to say "ahh."
7. CN 11—Patient shrugs shoulders against resistance. Patient turns head against resistance.
8. CN 12—Patient sticks out tongue. Patient puts tongue in cheek against resistance.

Additional spinal chord screening tests: performed **Y N** (See pages 3-5.)

Sensory:

1. Can patient (with closed eyes) differentiate sharp from dull double stimulation of hands and feet?
2. Proprioception of big toe with eyes closed: bend toe up and down and ask patient which direction it is bent.

Reflexes:

1. With hammer, check bicep, tricep, knee jerk, ankle jerk and Babinski reflex.
2. Flex patient's head and ask if there is any pain.

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