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PATIENT CONTENT

Anatomy of the Brain

The Multifaceted Functions and Growth of the Human Brain

by AANS

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PRINT

The brain serves many important functions. It gives meaning to things that happen in the world surrounding us. Through the five senses of sight, smell, hearing, touch and taste, the brain receives messages, often many at the same time.

The brain controls thoughts, memory and speech, arm and leg movements and the function of many organs within the body. It also determines how people respond to stressful situations (i.e. writing of an exam, loss of a job, birth of a child, illness, etc.) by regulating heart and breathing rates. The brain is an organized structure, divided into many components that serve specific and important functions.

The weight of the brain changes from birth through adulthood. At birth, the average brain weighs about one pound, and grows to about two pounds during childhood. The average weight of an adult female brain is about 2.7 pounds, while the brain of an adult male weighs about three pounds.

The Nervous System

The nervous system is commonly divided into the central nervous system and the peripheral nervous system. The central nervous system is made up of the brain, its cranial nerves and the spinal cord.

The peripheral nervous system is composed of the spinal nerves that branch from the spinal cord and the autonomous nervous system (divided into the sympathetic and parasympathetic nervous system).

The Cell Structure of the Brain

The brain is made up of two types of cells: neurons and glial cells, also known as neuroglia or glia. The neuron is responsible for sending and receiving nerve impulses or signals. Glial cells are non-neuronal cells that provide support and nutrition, maintain homeostasis, form myelin and facilitate signal transmission in the nervous system. In the human brain, glial cells outnumber neurons by about 50 to one. Glial cells are the most common cells found in primary brain tumors.

When a person is diagnosed with a brain tumor, a biopsy may be done, in which tissue is removed from the tumor for identification purposes by a pathologist. Pathologists identify the type of cells that are present in this brain tissue, and brain tumors are named based on this association. The type of brain tumor and cells involved impact patient prognosis and treatment.

The Meninges

The brain is housed inside the bony covering called the cranium. The cranium protects the brain from injury. Together, the cranium and bones that protect the face are called the skull. Between the skull and brain is the meninges, which consist of three layers of tissue that cover and protect the brain and spinal cord. From the outermost layer inward they are: the dura mater, arachnoid and pia mater.

Dura Mater: In the brain, the dura mater is made up of two layers of whitish, nonelastic film or membrane. The outer layer is called the periosteum. An inner layer, the dura, lines the inside of the entire skull and creates little folds or compartments in which parts of the brain are protected and secured. The two special folds of the dura in the brain are called the falx and the tentorium. The falx separates the right and left half of the brain and the tentorium separates the upper and lower parts of the brain.

Arachnoid: The second layer of the meninges is the arachnoid. This membrane is thin and delicate and covers the entire brain. There is a space between the dura and the arachnoid membranes that is called the subdural space. The arachnoid is made up of delicate, elastic tissue and blood vessels of varying sizes.

Pia Mater: The layer of meninges closest to the surface of the brain is called the pia mater. The pia mater has many blood vessels that reach deep into the surface of the brain. The pia, which covers the entire surface of the brain, follows the folds of the brain. The major arteries supplying the brain provide the pia with its blood vessels. The space that separates the arachnoid and the pia is called the subarachnoid space. It is within this area that cerebrospinal fluid flows.

Cerebrospinal Fluid

Cerebrospinal fluid (CSF) is found within the brain and surrounds the brain and the spinal cord. It is a clear, watery substance that helps to cushion the brain and spinal cord from injury. This fluid circulates through channels around the spinal cord and brain, constantly being absorbed and replenished. It is within hollow channels in the brain, called ventricles, that the fluid is produced. A specialized structure within each ventricle, called the choroid plexus, is responsible for the majority of CSF production. The brain normally maintains a balance between the amount of CSF that is absorbed and the amount that is produced. However, disruptions in this system may occur.

The Ventricular System

The ventricular system is divided into four cavities called ventricles, which are connected by a series of holes, called foramen, and tubes.

Two ventricles enclosed in the cerebral hemispheres are called the lateral ventricles (first and second). They each communicate with the third ventricle through a separate opening called the Foramen of Munro. The third ventricle is in the center of the brain, and its walls are made up of the thalamus and hypothalamus.

The third ventricle connects with the fourth ventricle through a long tube called the Aqueduct of Sylvius.

CSF flowing through the fourth ventricle flows around the brain and spinal cord by passing through another series of openings.

Brain Components and Functions

Brainstem

The brainstem is the lower extension of the brain, located in front of the cerebellum and connected to the spinal cord. It consists of three structures: the midbrain, pons and medulla oblongata. It serves as a relay station, passing messages back and forth between various parts of the body and the cerebral cortex. Many simple or primitive functions that are essential for survival are located here.

The midbrain is an important center for ocular motion while the pons is involved with coordinating eye and facial movements, facial sensation, hearing and balance.

The medulla oblongata controls breathing, blood pressure, heart rhythms and swallowing. Messages from the cortex to the spinal cord and nerves that branch from the spinal cord are sent through the pons and the brainstem. Destruction of these regions of the brain will cause “brain death.” Without these key functions, humans cannot survive.

The reticular activating system is found in the midbrain, pons, medulla and part of the thalamus. It controls levels of wakefulness, enables people to pay attention to their environments and is involved in sleep patterns.

Originating in the brainstem are 10 of the 12 cranial nerves that control hearing, eye movement, facial sensations, taste, swallowing and movements of the face, neck, shoulder and tongue muscles. The cranial nerves for smell and vision originate in the cerebrum. Four pairs of cranial nerves originate from the pons: nerves five through eight.

Cerebellum

The cerebellum is located at the back of the brain beneath the occipital lobes. It is separated from the cerebrum by the tentorium (fold of dura). The cerebellum fine tunes motor activity or movement, e.g. the fine movements of fingers as they perform surgery or paint a picture. It helps one maintain posture, sense of balance or equilibrium, by controlling the tone of muscles and the position of limbs. The cerebellum is important in one's ability to perform rapid and repetitive actions such as playing a video game. In the cerebellum, right-sided abnormalities produce symptoms on the same side of the body.

Cerebrum

The cerebrum, which forms the major portion of the brain, is divided into two major parts: the right and left cerebral hemispheres. The cerebrum is a term often used to describe the entire brain. A fissure or groove that separates the two hemispheres is called the great longitudinal fissure. The two sides of the brain are joined at the bottom by the corpus callosum. The corpus callosum connects the two halves of the brain and delivers messages from one half of the brain to the other. The surface of the cerebrum contains billions of neurons and glia that together form the cerebral cortex.

The cerebral cortex appears grayish brown in color and is called the "gray matter." The surface of the brain appears wrinkled. The cerebral cortex has sulci (small grooves), fissures (larger grooves) and bulges between the grooves called gyri. Scientists have specific names for the bulges and grooves on the surface of the brain. Decades of scientific research have revealed the specific functions of the various regions of the brain. Beneath the cerebral cortex or surface of the brain, connecting fibers between neurons form a white-colored area called the "white matter."

The cerebral hemispheres have several distinct fissures. By locating these landmarks on the surface of the brain, it can effectively be divided into pairs of "lobes." Lobes are simply broad regions of the brain. The cerebrum or brain can be divided into pairs of frontal, temporal, parietal and occipital lobes. Each hemisphere has a frontal, temporal, parietal and occipital lobe. Each lobe may be divided, once again, into areas that serve very specific functions. The lobes of the brain do not function alone: they function through very complex relationships with one another.

Messages within the brain are delivered in many ways. The signals are transported along routes called pathways. Any destruction of brain tissue by a tumor can disrupt the communication between different parts of the brain. The result will be a loss of function such as speech, the ability to read or the ability to follow simple spoken commands. Messages can travel from one bulge on the brain to another (gyri to gyri), from one lobe to another, from one side of the brain to the other, from one lobe of the brain to structures that are found deep in the brain, e.g. thalamus, or from the deep structures of the brain to another region in the central nervous system.

Research has determined that touching one side of the brain sends electrical signals to the other side of the body. Touching the motor region on the right side of the brain would cause the opposite side or the left side of the body to move. Stimulating the left primary motor cortex would cause the right side of the body to move. The messages for movement and sensation cross to the other side of the brain and cause the opposite limb to move or feel a sensation. The right side of the brain controls the left side of the body and vice versa. So if a brain tumor occurs on the right side of the brain that controls the movement of the arm, the left arm may be weak or paralyzed.

Cranial Nerves

There are 12 pairs of nerves that originate from the brain itself. These nerves are responsible for very specific activities and are named and numbered as follows:

1. **Olfactory:** Smell
2. **Optic:** Visual fields and ability to see
3. **Oculomotor:** Eye movements; eyelid opening
4. **Trochlear:** Eye movements
5. **Trigeminal:** Facial sensation
6. **Abducens:** Eye movements
7. **Facial:** Eyelid closing; facial expression; taste sensation
8. **Auditory/vestibular:** Hearing; sense of balance
9. **Glossopharyngeal:** Taste sensation; swallowing
0. **Vagus:** Swallowing; taste sensation
1. **Accessory:** Control of neck and shoulder muscles
2. **Hypoglossal:** Tongue movement

Hypothalamus

The hypothalamus is a small structure that contains nerve connections that send messages to the pituitary gland. The hypothalamus handles information that comes from the autonomic nervous system. It plays a role in controlling functions such as eating, sexual behavior and sleeping; and regulates body temperature, emotions, secretion of hormones and movement. The pituitary gland develops from an extension of the hypothalamus downwards and from a second component extending upward from the roof of the mouth.

The Lobes

Frontal Lobes

The frontal lobes are the largest of the four lobes responsible for many different functions. These include motor skills such as voluntary movement, speech, intellectual and behavioral functions. The areas that produce movement in parts of the body are found in the primary motor cortex or precentral gyrus. The prefrontal cortex plays an important part in memory, intelligence, concentration, temper and personality.

The premotor cortex is a region found beside the primary motor cortex. It guides eye and head movements and a person's sense of orientation. Broca's area, important in language production, is found in the frontal lobe, usually on the left side.

Occipital Lobes

These lobes are located at the back of the brain and enable humans to receive and process visual information. They influence how humans process colors and shapes. The occipital lobe on the right interprets visual signals from the left visual space, while the left occipital lobe performs the same function for the right visual space.

Parietal Lobes

These lobes interpret simultaneously, signals received from other areas of the brain such as vision, hearing, motor, sensory and memory. A person's memory, and the new sensory information received, give meaning to objects.

Temporal Lobes

These lobes are located on each side of the brain at about ear level, and can be divided into two parts. One part is on the bottom (ventral) of each hemisphere, and the other part is on the side (lateral) of each hemisphere. An area on the right side is involved in visual memory and helps humans recognize objects and peoples' faces. An area on the left side is involved in verbal memory and helps humans

remember and understand language. The rear of the temporal lobe enables humans to interpret other people's emotions and reactions.

Limbic System

This system is involved in emotions. Included in this system are the hypothalamus, part of the thalamus, amygdala (active in producing aggressive behavior) and hippocampus (plays a role in the ability to remember new information).

Pineal Gland

This gland is an outgrowth from the posterior or back portion of the third ventricle. In some mammals, it controls the response to darkness and light. In humans, it has some role in sexual maturation, although the exact function of the pineal gland in humans is unclear.

Pituitary Gland

The pituitary is a small gland attached to the base of the brain (behind the nose) in an area called the pituitary fossa or sella turcica. The pituitary is often called the "master gland" because it controls the secretion of hormones. The pituitary is responsible for controlling and coordinating the following:

- Growth and development
- The function of various body organs (i.e. kidneys, breasts and uterus)
- The function of other glands (i.e. thyroid, gonads, and adrenal glands)

Posterior Fossa

This is a cavity in the back part of the skull which contains the cerebellum, brainstem and cranial nerves 5-12.

Thalamus

The thalamus serves as a relay station for almost all information that comes and goes to the cortex. It plays a role in pain sensation, attention and alertness. It consists of four parts: the hypothalamus, the epythalamus, the ventral thalamus and the dorsal thalamus. The basal ganglia are clusters of nerve cells surrounding the thalamus.

Language and Speech Functions

In general, the left hemisphere or side of the brain is responsible for language and speech. Because of this, it has been called the “dominant” hemisphere. The right hemisphere plays a large part in interpreting visual information and spatial processing. In about one-third of individuals who are left-handed, speech function may be located on the right side of the brain. Left-handed individuals may need specialized testing to determine if their speech center is on the left or right side prior to any surgery in that area.

Many neuroscientists believe that the left hemisphere and perhaps other portions of the brain are important in language. Aphasia is simply a disturbance of language. Certain parts of the brain are responsible for specific functions in language production. There are many types of aphasias, each depending upon the brain area that is affected, and the role that area plays in language production.

There is an area in the frontal lobe of the left hemisphere called Broca’s area. It is next to the region that controls the movement of facial muscles, tongue, jaw and throat. If this area is destroyed, a person will have difficulty producing the sounds of speech, because of the inability to move the tongue or facial muscles to form words. A person with Broca’s aphasia can still read and understand spoken language, but has difficulty speaking and writing.

There is a region in the left temporal lobe called Wernicke’s area. Damage to this area causes Wernicke’s aphasia. An individual can make speech sounds, but they are meaningless (receptive aphasia) because they do not make any sense.

The AANS does not endorse any treatments, procedures, products or physicians referenced in these patient fact sheets. This information is provided as an educational service and is not intended to serve as medical advice. Anyone seeking specific neurosurgical advice or assistance should consult his or her neurosurgeon, or locate one in your area through the AANS’ “Find a Board-certified Neurosurgeon” online tool.

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