**Embryology**

- **Neurulation** begins with the formation of the neural plate, the neural folds and their ultimate fusion and closure as the **Neural Tube**.

- **Neural Plate** - thickening of embryonic ectoderm and adjacent mesoderm.

- **Neural Groove** - an invagination of the neural plate along its central axis.

- **Neural Folds** - thickening of the neural plate lateral to the neural groove. These folds continue to thicken and grow toward the midline until they meet and fuse leaving both ends open. (**Neuropores**)

- **Neural Tube** - fused neural folds.

**Normal Sonographic Anatomy**

**Spine**

Real-time examination is performed in at least 2 orthogonal planes of section. **Transversely**, the exam is begun in the proximal cervical spine and proceeds caudally. Attention is paid to:

- The location and configuration of the ossification centers in each vertebra
- The integrity of the musculature in the back
- The integrity of the skin line

**Sagittally or coronally**, the spine is examined to assess:

- Cervical and lumbosacral curvatures
- Sacral caudal tapering
- Configuration of vertebral ossification centers

Ossification centers dyed red in a 12-week abortus
BRAIN

**Axial sections** are obtained at multiple levels through the cerebral hemispheres. The following structures are identified:

- Cavum septum pellucidum (**C**)
- Both lateral ventricles (**V**)
- Thalami (**T**)
- Choroid plexus (**cp**)

Measurements are taken of:
- Atrium of a lateral ventricle (normal <10mm)
- Biparietal diameter
- Head circumference

**Axial oblique sections** are obtained through the posterior fossa and the following structures are identified:

- Cerebellum (**C**)
- Cisterna magna is measured (normal <10mm) (**cm**)
- Brain stem (**B**)

Sagittal lumbar spine demonstrating intact skin line, musculature, and parallel ossification centers tapering distally.

Axial section through sacro-iliac region demonstrating intact skin line and musculature. Normal sacral anatomy.
**Parts of the Brain**

The brain is generally divided into three major portions for anatomic study: forebrain, midbrain, and hindbrain.

**Forebrain**

*Cerebral hemispheres:* Largest part of the brain. Egg shaped and fills the whole of the upper portion of the skull. The entire surface, both upper and lower, is composed of layers of gray matter and is called the cortex.

*Fissures and Convolutions.* Deeper furrows are called fissures; the shallow ones, sulci, and the ridges between the sulci are called gyri or convolutions. The fissures and sulci are in-foldings of gray matter. There are five important fissures, which are landmarks:

- Longitudinal cerebral fissure
- Transverse fissure
- Central sulcus, or fissure of Rolando
- Lateral cerebral fissure, or fissure of Sylvius
- Parieto—occipital fissure

*Lobes of the Cerebrum:*

- **Frontal lobe:** portion of the cerebrum lying in front of the central sulcus. Usually consists of four main convolutions
- **Parietal lobe:** bounded in front by the central sulcus and behind by the parietooccipital fissure
- **Temporal lobe:** lies below the lateral cerebral fissure and in front of the occipital lobe.
- **Occipital lobe:** occupies the posterior extremity of the cerebral hemisphere. No external landmarks separate the occipital lobe from the parietal and temporal lobes.
Coronal section though the brain demonstrating major anatomical landmarks with sonographic correlation.

**Diencephalon:** connects cerebral hemispheres with the midbrain and forms the walls of the third ventricle.

- **Epithalamus**
- **Thalamus:** large bilateral, oval structures located above the midbrain. It receives all sensory impulses either directly or indirectly from all parts of the body with the exception of olfactory sensations. It also receives impulses from the cerebellum, cerebral cortex, and many nuclei.
- **Hypothalamus:** lies below the thalamus and forms part of the lateral walls and floor of the third ventricle. It is a control center for visceral activities by means of (1) neural connections with the posterior pituitary gland, the thalamus, and the midbrain, and (2) the blood supply to the pituitary gland, through which various “releasing factors” synthesized in the hypothalamus reach the pituitary and regulate hormonal secretion.

Sagittal schematic section though the brain demonstrating major anatomical landmarks with sonographic correlation.
Chapter 5: Fetal Central Nervous System

MIDBRAIN:
The midbrain (mesencephalon) is a short, constricted portion, which connects the pons and cerebellum with the hemispheres of the cerebrum. It is directed upward and forward and consists of:

- **Cerebral peduncles**: a pair of cylindrical bodies which are made up largely of the descending and ascending fiber tracts from the cerebrum above, the cerebellum, medulla, and spinal cord below.
- **Corpora quadrigemina**: four rounded eminences, which contain important correlation centers and also nuclei concerned with motor coordination (the superior colliculi for optic reflexes, the inferior for auditory reflexes).
- **Cerebral aqueduct (aqueduct of Sylvius)**, an intervening passage, or tunnel, which serves as a communication between the third and fourth ventricles.
- **Brain Stem**: the pons, the medulla, and the midbrain containing the cerebral and cerebellar peduncles, corpora quadrigemina, red nucleus, etc., are frequently called the brain stem.

HINDBRAIN:

- **Cerebellum**: occupies the lower and posterior part of the skull cavity. Below the posterior portion of the cerebrum, from which it is separated by the **tentorium cerebelli**, a fold of the dura mater. The constricted central portion is called the **vermis**, and the lateral expanded portions are called the **hemispheres**. The surface of the cerebellum consists of gray matter and is not convoluted but is traversed by numerous furrows, or sulci.
- **Cerebral peduncles**: The cerebellum is connected with the cerebrum by the **superior peduncles**, with the pons by the **middle peduncles**, and with the medulla oblongata by the **inferior peduncles**. These peduncles are bundles of fibers. Impulses from the motor centers in the cerebrum, from the semicircular canals of the inner ear, and from the muscles enter the cerebellum by way of these bundles.
- **Pons**: situated in the front of the cerebellum between the midbrain and the medulla oblongata.

Gross specimen demonstrating major parts of the midbrain with sonographic correlation.
**Medulla oblongata**: (spinal bulb) is continuous with the spinal cord, which on passing into the cranial cavity through the foramen magnum, widens into a pyramid-shaped mass which extends to the lower margin of the pons.

![Image of brain with labeled structures]

Gross specimen demonstrating parts of the hindbrain with sonographic correlation.

**MENINGES**
Three membranes cover the brain and are named from outer layer to inner layer:

- **Dura mater**: a dense membrane of fibrous connective tissue containing a great many blood vessels. The inner, or meningeal, portion covers the brain and sends projections inward for the support and protection of the different lobes of the brain.
- **Arachnoid mater**: a delicate fibrous membrane lying between the dura mater and the pia mater. The *subarachnoid space*, between the arachnoid mater and the pia mater, is a frequent site blood collection following trauma and surgery and is called a *subarachnoid hemorrhage*.
- **Pia mater**: a vascular membrane consisting of a plexus of blood vessels held together by fine areolar connective tissue.

**VENTRICULAR SYSTEM**
The brain contains cavities called *ventricles*.

- **Two lateral ventricles**: situated one in each of the cerebral hemispheres beneath the white fibers of the corpus callosum, which connects the two hemispheres. The *basal nuclei* of the brain are in the floor of the lateral ventricles.
- **Third ventricle**: posterior to the lateral ventricles. Connected with each one by means of small openings called the *foramina of Monro*.
- **Fourth ventricle**: lies in anterior portion of the cerebellum, behind the pons and the medulla. It
communicates with the third ventricle via the slender canal called the cerebral aqueduct (aqueduct of Sylvius). In the roof of the fourth ventricle there is an opening called the Foramen of Magendi. In the lateral walls there are, two openings called the foramina of Luschka. By means of these three openings, the ventricles communicate with the subarachnoid space, and the cerebrospinal fluid can circulate from one to the other.

**CEREBROSPINAL FLUID:**
The meningeal membranes and the spaces filled with fluid form a pad enclosing the brain and cord on all sides. Cerebrospinal fluid is secreted and diffused from the blood by the ependymal cells, which cover the choroid plexuses of the ventricles. The choroid plexuses are highly vascular folds or processes of the pia mater found in the ventricles.

*Flow of CSF:*
- Produced by choroid plexuses in lateral and 3rd ventricles
- Fills lateral ventricles first
- Flows into 3rd via foramen of Monro
- Flows into 4th via aqueduct of Sylvius

**BLOOD SUPPLY.**
The internal carotid and vertebral arteries are the source of blood to the brain. Their intracranial branches anastomose at the base of the brain to form the circle of Willis from which arise the three primary sets of cerebral arteries:
- **Anterior cerebral arteries:** arises from the internal carotid artery at the inner extremity of the Sylvian fissure. Passes anteriorly and medially to the longitudinal fissure where it is connected to the artery of the opposite side by the anterior communicating artery.
- **Middle cerebral arteries:** the largest branch of the internal carotid artery, which passes obliquely through the Sylvian fissure and, at the insula, divides into its terminal branches.
- **Posterior cerebral arteries:** branches of the basilar artery whose terminal branches penetrate the cerebral cortex.
- The cerebellum receives its arterial perfusion from various branches of the vertebral and basilar arteries.
Posterior communicating arteries connect the posterior cerebral arteries to the anterior circulation.

FETAL STRUCTURES

Cava septi pellucidi and Vergae lie between the frontal horns and bodies of the two lateral ventricles. The fornix is a landmark arbitrarily dividing this single structure into the cavum septi pellucidi anteriorly and the cavum Vergae posteriorly. During the 6th month of gestation, the cavum Vergae begins to close from posterior to anterior. This closure progresses to complete obliteration of the cavum septi pellucidi in 85% of infants by age 2 months. The cava septi pellucidi and Vergae normally do not connect with either subarachnoid or ventricular fluid. Care must be taken not to confuse either the cavum septi pellucidi with the inter-hemispheric fissure or the cavum Vergae with the third ventricle or with the cavum velli interpositi (CVI). The CVI, occasionally seen in conjunction with hydrocephalus, is triangular and lies between the cavum Vergae (or the fornices if the cavum Vergae is obliterated) and the roof of the third ventricle.
**Choroid plexus**: The choroid plexus of the lateral ventricle runs posteriorly from the tip of the temporal horn to arch around the thalami, then anteriorly in the floor of the body of the lateral ventricle, and to the foramen of Monro. It then passes through the foramen and with its counterpart runs posteriorly in the roof of the third ventricle to the suprapineal recess. In the temporal horn the plexus adheres to its roof medially and is thin, but as it passes around the thalami, in the region of the trigone opposite the occipital horn, it thickens to form the glomus. From the glomus, as it passes into the body of the lateral ventricle, it becomes thin again. At no time does the choroid plexus pass into the frontal or occipital horn.

Axial section through the head of an 18-week fetus demonstrating the echogenic choroids (c) bilaterally. There is a cyst in the downside choroid.