Medical Neuroscience | Tutorial Notes

Ventricles

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC1. The brain is the body's most complex organ.

LEARNING OBJECTIVES

After study of the assigned learning materials, the student will:

1. Describe the distribution of the ventricular spaces in the forebrain and brainstem.

NARRATIVE

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Overview

Now that you have acquired a framework for understanding the regional anatomy of the human brain, as viewed from the surface, and some understanding of the blood supply to both superficial and deep brain structures, you are ready to explore the internal organization of the brain. In the next set of tutorials from the brain anatomy lab, we will focus on the internal anatomy of the forebrain (recall that the forebrain includes the derivatives of the embryonic prosencephalon). Given the complexity of the brainstem and its importance for diagnosis and clinical practice, that portion of the brain will be addressed in a separate set of tutorials. Here, the focus will be on the ventricular system of the human central nervous system—the system of fluid-filled spaces in the human brain derived from the lumen of the embryonic neural tube.

The ventricular system

As a point of emphasis for this tutorial, remember that the ventricles are the product of the morphogenic events that bent, pinched and expanded the lumen of the embryological neural tube and greatly increased the thickness and complexity of its walls (now that's an understatement!). The objective of this tutorial is to recognize the various compartments that constitute the ventricular system of the adult brain. This will entail recognizing four principal ventricles, the paired **lateral ventricles**, the **third ventricle**, and the **fourth ventricle**, as well as three narrow channels, the paired **interventricular foramina**, and the single (midline) **cerebral aqueduct**.

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

If you have a copy of *Neuroscience, 5th Ed.*, begin by becoming familiar with **Figure A23**[2]. If you have access to a digital brain atlas, such as ***Sylvius4 Online***, then open the atlas views in the coronal plane and be prepared to step through the brain from anterior to posterior.

Begin passing through the brain from anterior to posterior and note the appearance of the frontal horn of the lateral ventricle as it first appears. With your attention on the lateral ventricle, continue sectioning and note the appearance of the temporal horn of the lateral ventricle in the medial temporal lobe. Finally, note the caudal extension of the lateral ventricle as it penetrates the occipital lobe as the occipital horn of the lateral ventricle.

Now, re-slice the forebrain in the axial (horizontal) plane from dorsal to ventral. Look for these same compartments within the lateral ventricle. Do you notice how the lateral ventricle opens widely in its central part or body, then appears more posteriorly in a region called the atrium before appearing more anteriorly in the temporal lobe?

To appreciate the third ventricle, look for the narrow slit-like space along the midline at the medial base of the diencephalon The **interventricular foramina** (of Monroe) provide the means for cerebrospinal fluid (CSF) flow to from each lateral ventricle, where it is synthesized by **choroid plexus**, into the third ventricle. Note that the two lateral ventricles are separated by a thin wall called the **septum pellucidum**. Thus, CSF produced in the lateral ventricles first mixes in the third ventricle.

The third ventricle communicates with the fourth ventricle by means of a narrow channel through the dorsal midbrain (mesencephalon) called the **cerebral aqueduct**. The cerebral aqueduct is a principal landmark that will always help you identify transverse sections through the midbrain. From here, continue sectioning through the brainstem in the caudal direction and note the gradual expansion of the cerebral aqueduct as you enter the pons. By the middle of the pons, the cerebral aqueduct has fully opened up into the **fourth ventricle**. This most caudal ventricle in the adult brain lies between the dorsal surface of the pons and the large stalks of white matter (the cerebellar peduncles; “peduncle” means stalk) that connect the cerebellum to the brainstem.

The circulation of CSF

From the foregoing account, it should be clear that CSF flows from the lateral ventricles, through the interventricular foramina, into the third ventricle, through the cerebral aqueduct and into the fourth ventricle. Actually, there is choroid plexus in each ventricle so some CSF is produced in each; but given the large size of the lateral ventricles, these are the major produces of CSF. This may be surprising, but the choroid plexus produces 2-3 times as much CSF every day as can be contained in the brain, the cranial vault, and the spinal column. Thus, the entire volume present in the system is turned over several times a day. Thus, obstruction of CSF flow results in an excess of cerebrospinal fluid in the intracranial cavity, a dangerous condition called hydrocephalus (literally, “water head”) that can lead to enlargement of the ventricles and compression of the brain. But how does the CSF leave the brain and ultimately return to the venous vascular system?

Cerebrospinal fluid percolates through the ventricular system and flows into the subarachnoid space through perforations in the thin covering of the fourth ventricle (through a midline foramen of Magendie and two lateral foramena of Luschka). Once outside of the fourth ventricle, CSF flows in between the pia mater and the arachnoid mater in the **subarachnoid space**. CSF eventually passes through specialized structures called **arachnoid villi** or **arachnoid granulations** along the dorsal midline of the forebrain (see **Figure A21**). These granulations are essentially one-way valves that communicate

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

between the subarachnoid space and a prominent, midline dural sinus, called the **superior sagittal sinus**. Thus, CSF is returned to the venous circulation via the system of dural sinuses that eventually form the jugular veins in the base of the cranium.

STUDY QUESTIONS

Q1. Which structure produces **cerebrospinal fluid**?

A. choroid plexus
B. pineal gland
C. arachnoid granulations
D. cisterna magna
E. pituitary gland

Q2. Which statement below most accurately describes the components of the **ventricular system** and/or the circulation of cerebrospinal fluid (CSF)?

A. CSF flows directly from one lateral ventricle through an aperture in the septum pellucidum into the other lateral ventricle.
B. The third ventricle is lies posterior to the fourth ventricle.
C. The lateral ventricle is associated with the midbrain.
D. CSF circulates around the entire central nervous system in the subarachnoid space.
E. CSF flows into the subarachnoid space via apertures in the third ventricle.