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Original Article

Three dimensional (3D) reconstruction of the rat ventricles

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ABSTRACT

The aim of this study is to investigate the normal three dimensional (3D) shape of the ventricular system of rat brain. The shape and volume of ventricles can be correlated with clinical or other characteristics of illness. Recently, many diagnostic imaging techniques allow to get the 3D images of anatomical structures easily. So it is possible to determine the correlation between subjects and pattern of the structures. In this study, we constructed a 3D model of the rat ventricles and their related structures. It is possible to say that, ventricular system of rat brain was similar to the human's completely. Understanding such patterns may eventually help to improve rat experiments' vision. Furthermore, these 3D models can be used for virtual animations and stereotaxic trials in further studies. ***Neuroanatomy; 2005; 4: 49–51.***

Key words [rat brain] [ventricular system] [anatomy] [computer] [3D reconstruction]

Introduction

Ventricular system is a brain area that can be effected by numerous disorders like psychiatric disorders, particularly schizophrenia and Alzheimer [1, 2]. Furthermore, some changes during the biologic course of aging are also seen [3]. Nowadays, many studies are being done on the ventricular system. In these studies, the most preferable animal is rat, because of the similarity of the histological structure of the ventricles to that of human. It is important to determine the exact border of this area pertinent to basic and clinical sciences.

To improve the understanding of the ventricles' anatomy, we created three-dimensional (3D) models of rat ventricular system. This 3D model helps to understand the complex anatomic structure with ease. At the same time, 3D images may be used as a tool for virtual reality modeling of the ventricular system on planning the stereotaxic trial formerly. We are of opinion that this study will be useful for the neuroscientists in studies on ventricular system morphology and quantitative analysis.

Material and Methods

This experimental study was performed in a 6-month-old male Wistar rat, weighting 240 g and fed in a pathogen-free environment. The animal was anaesthetized with ketamine hydrochloride (Ketalar, Parke-Davis, Istanbul, Turkey) 30 mg/kg intramuscularly. For muscle relaxation 2% xylazine hydrochloride (Rompun, Bayer, Istanbul, Turkey) 6 mg/kg was used. The animal was decapitated, the brain was removed by craniotomy and frozen in cryostat (Leica CM3050) at –50°C. The frozen brain was cut in horizontal plane at a thickness of 60 μm with the cryostat at –15°C. Sections were stained with [4–6] hematoxylin-eosin (Fig. 1). After the staining, we examined the preparations in light microscope (Fig. 2). We scanned all the preparations. After the scanning of each slice, the images were imported to the computer [7]. Lazonoff and his co-workers [8] developed Surf Driver, a commercially distributed PC and Mac based program is used for reconstructing the 3D coordinate models from serial sections.

Results

Ventricular system of rat were like "Y" in shape, similar to human ventricles mentioned in textbooks (Fig. 3). Basically, the lateral venrtricles were the first and second ventricles. They were connected to the third ventricle of the diencephalon by the interventricular foramina. Continuing caudally, the cerebral aqueduct of the midbrain opened into the fourth ventricle. The fourth ventricle occupied the space dorsal to the pons and medulla and ventral to the cerebellum. It can be said that rat ventricular system was similar to human's one (Fig. 4).

Additionally, we also reconstructed brain hemispheres, and cerebellum. So, the 3D position of the ventricular system relative to the brain is observed. With computer aid, it was possible to rotate all the figures at 360 degrees, thus we saw all the structure from different angles. It was also possible to magnify or zoom out the figures. Furthermore, the software allowed one to delete or add any structure to the image; also to view the complete model. These images were basic for advanced search. But, they contributed to improve the understanding of the ventricles of the brain and related organs of rat.

Discussion

In human, the central canal of the embryo differentiates into the ventricular system of adult brain. The ventricular cavities are filled with cerebrospinal fluid (CFS), which is produced by vascular tufts called choroid plexus. The ventricular cavity of the telencephalon is represented by the lateral ventricles. The lateral venrtricles are the first and second ventricles. They connect to the third ventricle of the diencephalon by the interventricular foramina (of Monro). Continuing caudally, the cerebral aqueduct of the midbrain opens into the fourth ventricle. The fourth ventricle occupies the space dorsal to the pons and medulla and ventral to the cerebellum. Cerebrospinal fluid flows from the fourth ventricle to the subarachnoid space trough the median aperture (of Magendie) and the

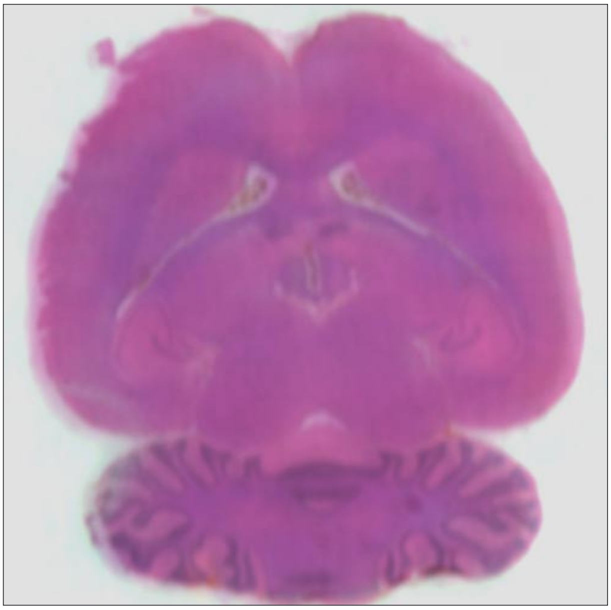

Figure 1. Sections taken from a 6-month-old male Wistar rat brain stained with hematoxylin-eosin. Preparations were examined in light microscope, then the serial images were imported to computer.

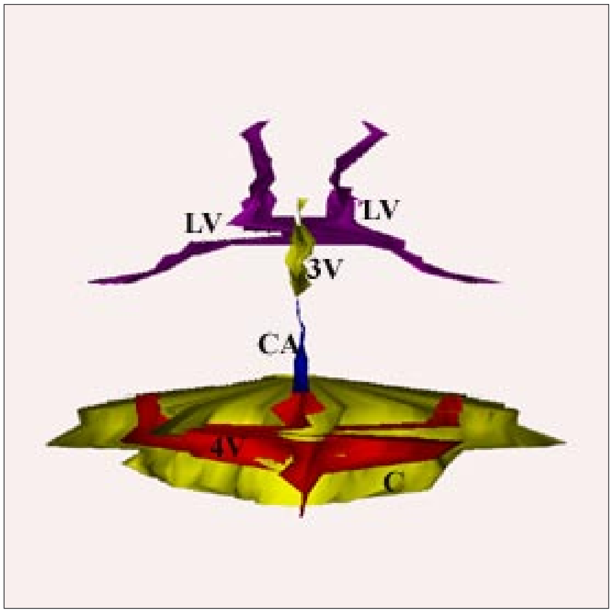

Figure 2. 3D view of rat ventricles. *(**LV:** lateral ventricle; **3V:** 3th ventricle; **CA:** cerebral aqueduct; **4V:** 4th ventricle; **C:** cerebellum)*

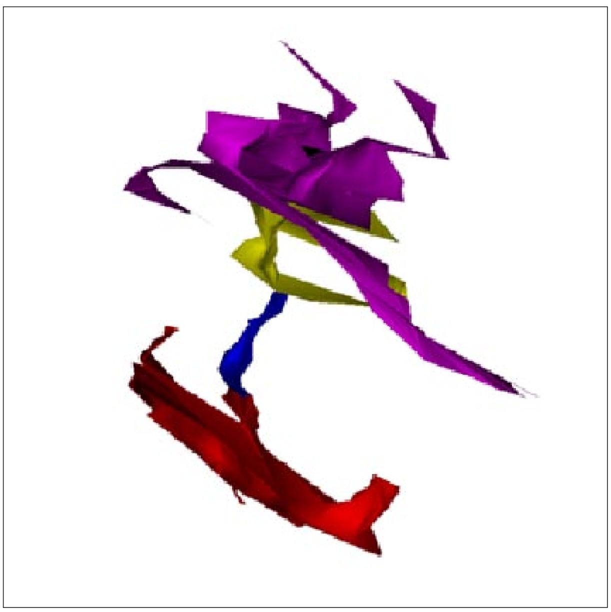

Figure 3. A 3D reconstruction view of the rat ventricles from left antero-infero-lateral angle.

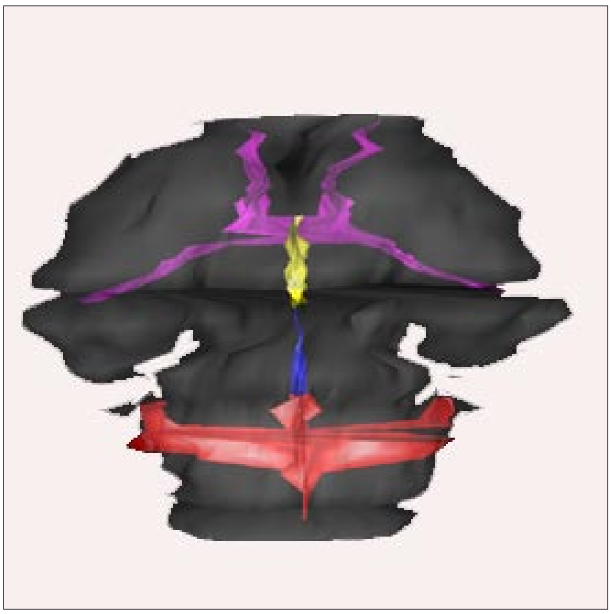

Figure 4. Reconstruction of the ventricles with brain.

lateral apertures (of Luschka). Most of the cerebrospinal fluid is produced by the choroid plexus of the lateral ventricles, although tufts of choroid plexus are found in the third and fourth ventricles as well [9].

The structures that construct the ventricular system of the rat were similiar to human in this study. This result was more comprehensible with the 3D model by the means of the possibility to rotate, zoom in or zoom out the 3D images. Thus, one can easily examine the structures from different angles. This model contributed to a new vision to the rat ventricular system, as well as to human.

In human, results of ventricular system shape and volume examination are used in diagnosis; the lateral as well as the third ventricles have been noted to be enlarged in a number of psychiatric disorders, particularly in schizophrenia [10, 11]. Enlargement of the ventricles usually reflects atrophy of surrounding brain tissue. The term hydrocephalus is used to describe abnormal enlargement of ventricles. In the condition known as normal pressure hydrocephalus, the ventricles enlarge in the absence of brain atrophy or obvious obstruction to the flow of the CSF. Normal pressure hydrocephalus is classically characterized by progressive dementia, ataxia, and incontinence [12]. In addition, ventricular system changes in Alzheimer disease [13].

In human, with the imaging techniques like computed tomography (CT), magnetic resonance imaging (MRI) and others, we can easily demonstrate the ventricular system and related organs. So, it is possible to follow up the changes in the shape or functions of the ventricular system. Physicians usually correlate the outline with the disease. This is also done in rat experiments, and became the subject of many investigations. Consequently, there have been many studies of the ventricular system both on human and rats. Therefore, it is important to improve the understanding of the hippocampus of rat, as well as the one of human.

Furthermore, 3D models that developed in this study can be used in creating virtual simulations, and volumetric studies. Because of the surgical interventions can be hard in small animal brains like rat, surgeons can practice on this computer assisted models, especially in stereotaxic trials. This study may also contribute to a new vision in rat studies.

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