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Structure and individual anatomical variability of the lobules IV V of the human cerebellar hemispheres

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Abstract:

The aim of the present study was to determine morphological variations in the lobules IV-V of the human cerebellar hemispheres.

Material and methods. The research involved cerebella of 100 people of both sexes, who died of causes unrelated to brain pathology at the age of 20-95. The parasagittal sections of the cerebellum were investigated. Possible variations in the size, shape and peculiarities of branching of the white matter in the lobules IV-V of the cerebellar hemispheres were investigated.

Results. Complex branched white matter is the basis of the IV-V lobules of human cerebellar hemispheres. The shape of the IV-V lobules is quite varied. Differences of the structure of these lobules depend on the characteristics of the branching of the white matter. The shape of the lobule depends on location of the section. Structure of the lobules is different on serial parasagittal sections. We described 2 variants of branching of the white matter of the hemispheric lobules IV-V at a distance 5 mm from midsagittal section (the 2nd variant is the most common) and 10 common variants of the shape of IV-V lobules (10 mm from midsagittal section); the third variant is the most common variant of the lobule IV; the first, second, and third variants are the most common shape variants of the lobule V.

Conclusion. Described variants of the shape of the cerebellar lobules can be used as criteria standards of modern diagnostic imaging techniques for the diagnosis of various diseases of the CNS.

Keywords: cerebellum, human, individual anatomical variability

Introduction:

In recent years, the study of the peculiarities of individual anatomical variability of the structures of the central nervous system is an actual direction of research of modern neuromorphology. Among all structures of the central nervous system cerebellum has the most complex spatial configuration which is associated with the organization of the arbor vitae ("Tree of Life") – tree-like branched white matter, which is structural basis of its cortex.[1]

Morphological changes of cerebellar lobules were found in many congenital and acquired diseases of the cerebellum (hereditary Marie's ataxia, olivocerebellar atrophy (Holmes type), cerebellar atrophy of the Marie-Foix-Alajouanine syndrome, olivopontocerebellar degeneration, Dandy-Walker syndrome, Arnold-Chiari IV malformation,

Alzheimer's disease, multiple sclerosis, cerebellar alcohol degeneration, etc).[2-4] Morphological changes of the cerebellar lobules (the change of volume segments, volume and structure of gray and white matter) in various mental disorders (namely autism, attention deficit disorder with hyperactivity, dyslexia, schizophrenia, bipolar spectrum disorders) were revealed.[5-10] In recent years, due to modern imaging techniques (MRI, fMRI, CT, SPECT, PET) morphological changes of the hemispheric and vermal lobules occurring in these diseases can be detected in vivo, which is essential for early and accurate diagnosis. However, information about normal structure of the cerebellum on which criteria of imaging diagnostic methods are based, does not take into account the features of individual anatomical variability.

The aim of the present study was to determine morphological variations in the lobules IV-V of the human cerebellar hemispheres.

Material and methods:

The research was conducted at the Kharkiv Regional Bureau of Forensic Medicine. It involved cerebella of 100 people of both sexes, who died of causes unrelated to brain pathology at the age of 20-95. During the forensic autopsy the cerebellum and brain stem were separated and fixed during one month in 10% formalin solution. Serial sections of the cerebellum were performed in the central sagittal and parasagittal planes with a step-by-step interval of 5 mm. Possible variations in the size, shape and branching of the white matter in the lobules IV-V of the cerebellar hemispheres were investigated.

Results and Discussion:

Lobules IV-V of the cerebellar hemispheres are anatomically closely interrelated, they have the same plan of structure and similar features of anatomical variability. These lobules are the constituent parts of the anterior quadrilateral lobule or Culmen of the cerebellum.

Lobules IV and V are an extension of lobes IV and V of the cerebellar vermis in the lateral direction. The shape of hemispheric lobules IV-V is similar to a tetrahedral prism, the long axis of which is directed in the horizontal plane from the medial parts of the cerebellum (from the vermis) to the lateral surfaces of the hemispheres.

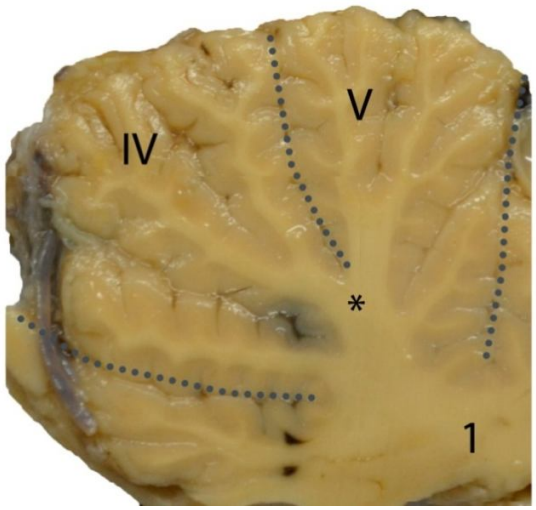
The white matter of the lobules IV-V consists of the main trunk (common to the two lobules). Common main trunk is divided into the main trunks of the lobules IV and V, which are dichotomously divided into different numbers of secondary branches. In the lateral regions of the hemispheres (15-50 mm from the median sagittal plane) the lobules IV and V are completely separated from each other.

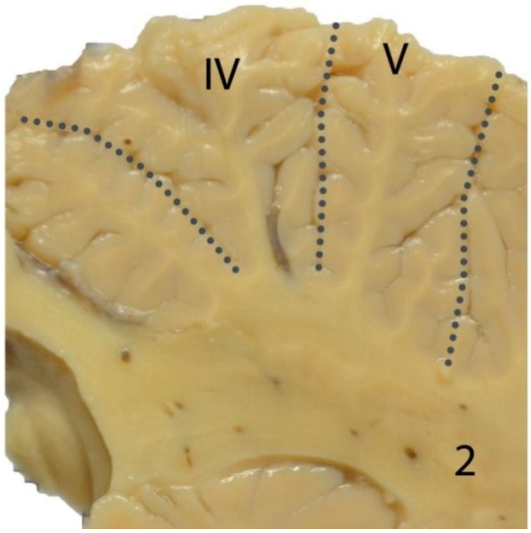
We described that the place of dividing of the common main trunk into the individual trunks of lobules IV and V was located at different distances from the central sagittal plane. Most often, the main trunk was divided at a distance of 5 mm from the median sagittal plane (51% of cases in the left hemisphere, 64% in the right hemisphere), less often at a distance of 10 mm (42% on the left, 32% on the right), most rarely at a distance of 15 mm (2% on the left, 1% on the right). In some cases, the main trunk was not completely divided into 2 main branches, and the main trunks of the lobules IV and V were interconnected in the lateral regions of the hemispheres. This variant of the structure was found in 5% of cases in the left hemisphere, in 3% in the right hemisphere.

Taking into account the peculiarities of the structure of the main trunk of the white matter, we described 2 variants of the structure of the white matter of the lobules IV-V at a distance of 5 mm from the median plane (Fig. 1). In the first variant, the white matter of the two lobules had the Y-like branching: there was a common main trunk, which was divided into 2 secondary branches. This variant was found in 49% of cases in the left hemisphere and 36% of cases in the right hemisphere. In the second variant, both lobules had separate, unrelated main trunks of white matter at a distance of 5 mm from the median plane. This variant was found in 51% of cases in the

left hemisphere, 64% of cases in the right hemisphere. These variants were different in the right and left hemispheres in 57% of cases, and corresponded in both hemispheres in 43% of cases.

Figure 1. Variants of the structure of IV and V lobes of the hemispheres, 5 mm from the median sagittal plane. Lobules are denoted by roman numerals, * is the main trunk of the white matter (common to the IV and V lobules).

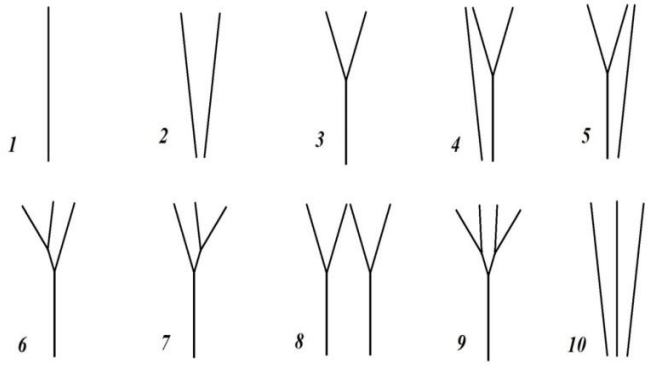




The parasagittal section of the cerebellum at a distance of 10 mm from the medial sagittal plane corresponds to the medial part of the hemispheres. In this section, the trunks of lobules IV and V were separated from each other and divided into secondary branches.

The number of secondary branches varied from 1 to 4. Depending on the characteristics of the branching of the white matter, we described 10 variants of the branching of the white matter of the hemispheric lobules IV-V (Fig. 2).

Figure 2. Variants of the shape of the lobules IV and V of the cerebellar hemispheres (scheme of branching of white matter), 10 mm from the median sagittal plane.



The first variant: the main trunk was not divided into secondary branches.

The second variant: the white matter of the lobule included 2 separate branches.

The third variant: the main trunk of white matter was divided into 2 secondary branches.

The fourth variant: the white matter of the lobule included 2 separate branches (upper and lower); the lower branch was divided into 2 secondary branches.

The fifth variant: the white matter of the lobule included 2 separate branches (upper and lower); the upper branch was divided into 2 secondary branches.

The sixth variant: the main trunk of white matter was divided into 2 secondary branches (upper and lower); the upper branch was divided into 2 secondary branches.

The seventh variant: the main trunk of white matter was divided into 2 secondary branches (upper and lower); the lower branch was divided into 2 secondary branches.

The eighth variant: the white matter of the lobule included 2 separate branches (upper and lower); both branches were divided into 2 secondary branches.

The ninth variant: the main trunk of the white matter was divided into 2 secondary branches (upper and lower); both branches were divided into 2 secondary branches.

The tenth variant: the white matter of the lobule included 3 separate branches.

These variants of the branching of white matter were found in different number of cases, the prevalence of these variants is given in Table. 1.

Table 1. Prevalence of variants of the branching of white matter of lobules IV-V of human cerebellar hemispheres (%)

Varia-nt type	Lobule IV Branching Prevalence in %		Lobule V Branching Prevalence in %	
	Left hemisphere	**Right hemisphere**	**Left hemisphere**	**Right hemisphere**
1	11	13	31	38
2	14	12	20	23
3	43	53	40	35
4	4	1	3	1
5	9	6	1	0
6	7	5	1	1
7	11	9	0	1
8	1	0	1	0
9	0	0	1	1
10	0	1	2	0

The total number of branches of the lobules IV and V varied from 2 to 6, the prevalence of a different number of branches is given in Table 2.

The prevalence of the places of termination of the branches in the lateral regions of the hemisphers is given in Table 3. The first branch is the upper (rostral) branch; the sixth branch is the lower one (caudal).

Table 2. Number of branches of white matter of the lobules IV-V of the human cerebellar hemispheres

Common number of branches of white matter	**Prevalence, %**	
	Left hemisphere	Right hemisphere
2	3	4
3	31	37
4	49	48
5	14	11
6	3	0

Table 3. The prevalence of the places of termination of the branches of the IV-V hemispheric lobules in the lateral regions of the hemispheres

Place of termination of the branches, distance from medial sagittal plane in mm		**10 mm**	**15 mm**	**20 mm**	**25 mm**	**30 mm**	**35 mm**	**40 mm**
Right Hemisphere Number of branches prevalence in %	**1**	13	26	35	20	6	0	0
	2	4	16	28	39	10	3	0
	3	1	5.2	22.7	28.9	36.1	4.1	2.1
	4	0	3.03	15.2	28.8	30.3	19.7	3.03
	5	6.7	0	13.3	26.7	33.3	20	0
	6	0	33.3	0	0	33.3	33.3	0
Left Hemisphere Number of branches prevalence in %	**1**	13	32	27	22	5	1	0
	2	6	19	29	25	20	1	0
	3	0	8.3	24	29.2	26	11.5	1
	4	0	3.33	11.7	35	30	18.3	1.67
	5	0	0	0	78	25	0	0
	6	0	0	0	0	0	0	0

As can be seen from the data in Table 3, the upper branches were terminated in the medial regions of the hemispheres, and the lower branches were terminated in the lateral sections.

Conclusion:

Thus, individual variability of the structure of the lobules IV-V of the cerebellar hemispheres was found, namely the white matter branching features. These lobules have similar white matter branching. We described two variants of the branching of the white matter of IV-V lobules at a distance of 5 mm from the median sagittal plane (the 2nd variant is the most common) and 10 variants of the shape of these lobules at a distance of 10 mm from the median sagittal plane (the 3rd variant is the most common variant of the lobule IV; the first, second, and third variants are the most common variants of the lobule V). The total number of branches of the lobules IV and V varies from 2 to 6. In about half of the cases, the lobule consists of four branches of white matter. Described variants of the cerebellar lobules shape could be used as criteria standards of modern diagnostic imaging techniques for the diagnosis of various diseases of the CNS.

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