PLANIMETRIC CHARACTERISTICS OF CORPUS CALLOSUM SAGITTAL PROFILE IN MIDDLE- AND ADVANCED AGED MEN

[1]Boiagina O., [2]Kostilenko Yu.

[1]Kharkiv National Medical University; [2]HSEIU "Ukrainian Medical Stomatological Academy", Ukraine

The introduction of the methods of magnetic resonance imaging into the practice of morphofunctional study of human brain has qualitatively improved the possibilities of studying the corpus callosum under conditions of norm and pathology [9-15,17]. In addition, in the first case, interest comes down to determining its age-related changes, sexual dimorphismus, and the refinement of topographic mapping of commissural nerve conductors, which perform associative interaction between the corresponding contralateral centers of the new cortex [3,9-12,14,16,17]. Given that the research is carried out in the intravital state, MRI imaging methods currently allow solving many problems in this aspect of neuromorphology. However, it should be borne in mind that they still have insufficient resolving power to distinguish the anatomical details.

It is commonly known that, due to its complex spatial configuration the corpus callosum in MR imaging proves to be reasonably accessible for visual examination in only one perspective, which is called its sagittal section and corresponds to its appearance on the medial surface of the cerebral hemispheres that has a bodily outline of a kind of staple with two opposite thickenings – the genu and the splenium with the truncus section between them. In this perspective, the corpus callosum becomes available for morphometric studies to determine its age-related changes and sexual dimorphism, which is now mainly achieved with the help of MR tomography. At present different computational operations using metric values of conditional linear distances are used for these purposes [8,14].

In this process the opportunity to determine the total area of the corpus callosum sagittal profile along the length of its closed contour circle is lost, which is a more complete expression of its digital characteristics. At present, the solution of this problem is simplified due to the availability of a special computer program for calculating the area, which we successfully used in the planimetry of MRI images of the adult people corpus callosum [3].

The aim of the work is to determine the differences between planimetric indices of corpus callosum of men in the first and second periods of mature age and the elderly ones, using photographs of the medial surface of brain hemispheres.

Material and methods. The material used was 65 total brain preparations of men aged from 22 to 73 years who died for reasons not related to the pathology of the central nervous system. The material samples was taken in the Kharkov Regional Bureau of Forensic Medical Examination under the contract with Kharkov National Medical University.

After a two-week fixation in 10% neutral formalin solution, the brain was dissected along the longitudinal fissure of cerebrum into two hemispheres with a plate-shaped knife. One of hemispheres was used to photograph its medial surface with a superimposed measuring scale.

The received photos were standardized according to their format and used to determine the basic metric parameters and to conduct the planimetric study of the corpus callosum sagittal profile using the Adobe Photoshop CS6 Extended computer program. One of the presentative examples of this is shown in Fig. 1.

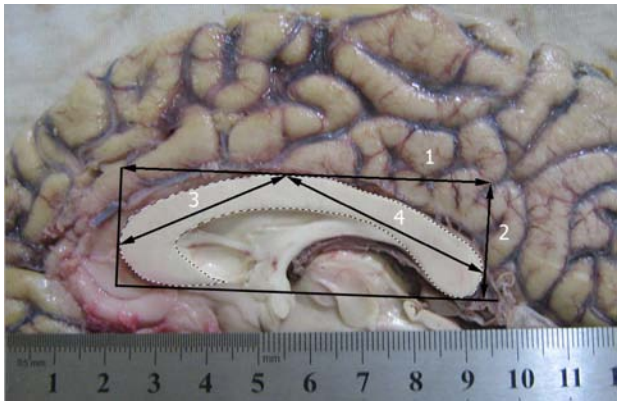

Fig. 1. The medial surface of the human brain hemisphere in adulthood.
1 - longitudinal size of the corpus callosum along the constricting chord; 2 - maximum height of the truncal convex of the corpus callosum; 3 - length of the anterior truncal thigh; 4 - length of the posterior truncal thigh. The dashed line indicates the perimeter of the sagittal profile of the corpus callosum

Results and their discussion. At first, all the results of planimetric analysis of the total sample of anatomical preparations of male corpus callosum sagittal profile in a broad chronological range (from 22 to 73 years) were divided into three age groups. The first of them included 20 preparations (from 22 to 35 years) presented the first period of adulthood, the second group presented the second period of adulthood (25 preparations - from 36 to 60 years), and the third group presented advanced age (20 preparations - from 61 to 73 years). All of them are separately presented in the general summary Table 1.

But before starting to analyze the numerical data presented in the table, it makes sense to get acquainted with a brief evaluation of the examination results of the photographs of corpus callosum anatomical preparations after formalin fixation. In this regard, it is appropriate to say that under standardized conditions of material taking and

Table 1. Planimetric indices of the corpus callosum of men of three age periods (first and second periods of adulthood and advanced age)

Age periods	№№	Age (years)	Area of the saggital section of corpus callosum, mm^2
Adulthood, I period	1	22	751,4
	2	22	585,6
	3	23	843,2
	4	24	815,8
	5	24	760,5
	6	25	768,7
	7	26	564,1
	8	27	861,2
	9	27	722,2
	10	29	795,7
	11	30	930,7
	12	31	593,4
	13	31	612,6
	14	32	744,1
	15	32	749,8
	16	33	766,1
	17	33	798,8
	18	35	847,7
	19	35	559,4
	20	35	879,0
	M±m		747,5±110,4
Adulthood, II period	1	37	809,9
	2	38	763,7
	3	38	538,5
	4	38	616,1
	5	40	689,7
	6	40	773,9
	7	41	612,0
	8	43	651,9
	9	43	837,1
	10	45	650,0
	11	46	527,3
	12	49	572,1
	13	50	865,6
	14	52	709,6
	15	53	540,6
	16	53	777,4
	17	53	817,8
	18	54	798,1
	19	54	854,3
	20	55	721,6
	21	56	618,5

	22	56	868,4
	23	58	486,5
	24	58	603,3
	25	60	412,4
	M±m		684,7±130,0
Advanced age	1	61	703,4
	2	61	668,6
	3	61	602,2
	4	62	620,6
	5	62	737,5
	6	62	800,2
	7	63	441,3
	8	63	827,7
	9	63	706,2
	10	64	493,2
	11	64	688,6
	12	65	803,2
	13	67	482,3
	14	67	603,3
	15	67	867,2
	16	68	542,6
	17	68	688,2
	18	68	523,5
	19	72	661,4
	20	73	543,3
	M±m		650,2±121,9

fixation time in a 10% solution of neutral formalin (which we strictly observed) changes in the corpus callosum, if they occur, are equal and uniform in all preparations, while retaining its original form.

Formerly, studying the shape of the corpus callosum by MR tomograms [2], we found a great variety of its external outline (configuration), which arises from the proportional combination of the variable shape of its individual parts (genu, splenium and truncus), as well as the degree of its truncus convexity manifestation, which is inversely related to the length of the cerebral cranium. At the same time, we must understand that the anatomical preparations of the corpus callosum that we studied present a completely different (and more numerous) random sample in relation to that of its MR tomograms. Due to this fact we had to testify to some discrepancy in the invariance between them that is quite predictable when dealing with accidental, secondary morphological features that arise in the process of individual development. As a matter of fact, in order to analyze the whole variety of such morphological features, one could resort to well-known combinatorial formulas (a branch of mathematics that studies different combinations-compounds), resulting in a large number of configuration variations of the corpus callosum sagittal profile, including not only the ones present in our two samples (MR-tomograms and anatomical preparations), but also other probable ones. However, such combinatorial analysis would be excessively superfluous since, because of the large number of variants, the specific registration of them would be practically impossible. Nevertheless, they can be classified according to the frequency of predominance of one single variable trait (the shape of the rostral section of the corpus callosum, its truncus and splenium). But the most representative difference in the shape of the corpus callosum is expressed by the degree of convexity of its truncus department. According to this feature, in the whole variety of its configurations there are mainly three distinctly different forms, which we distinguish as low convex, medium convex and high convex [2].

We believe that if the configurational features of the corpus callosum are inessential and secondary anatomical features that depend entirely on the developing conditions of the individual development of the brain (which may have significance in stereotaxic practice), then its dimensional parameters must be determined by the genotype of the subject, and may be associated with its psychological properties. In our opinion, in this respect, the most significant metric parameter is

the total area of its sagittal profile, if we proceed from the consideration that it depends on the total of nerve conductors that surround it.

First of all, when evaluating general results of the planimetric analysis of the male corpus callosum sagittal profile presented in the matrix of the summary Table 1, we took notice of the fact that within each age group there is a wide scatter of the individual digital values of its area and the random irregular nature of their distribution that does not depend on the intra-group age chronology. This feature of the irregular spread of planimetric data is more accessible for perception when expressed in the distribution of their minimum and maximum values, which are highlighted in blue and red respectively in the table. Thus, in the first period of adulthood, the minimum value of the area of corpus callosum sagittal profile is rounded to 560 mm^2, while the maximum value is 930 mm^2 (the average value is 747.5 ± 110.4 mm^2). In the second period of adulthood, somewhat lower indicators are indicated; the minimum value of it is equal to 412 mm^2, while the maximum value is 868 mm^2 (the average is 684.7 ± 130.0 mm^2). In the advanced age, we find them in the range between 441 and 867 mm^2 (the average value is 650.2 ± 121.9 mm^2), which is approximately comparable to the previous period and noticeably inferior to the first period of adulthood. With a view to a more expressive demonstration of this difference, we resorted to constructing a diagram in which the above-mentioned planimetric indices of the corpus callosum of three age periods of men are placed in a comparative series (Fig. 2). This diagram clearly shows that a noticeable step toward a decrease in the area of the corpus callosum is recorded between the first and second periods of adulthood, and the planimetric parameters between advanced age and the previous period differ only slightly. If we take into account the data given in the literature [1,4-7,16], according to which the aging process of the organism leads to a slight decrease in the total mass of the brain, then the recorded decreases in planimetric indices of the corpus callosum in the advanced age are quite natural. And it may be that this process, individually in different ways, has a beginning somewhere in the second period of mature age, which is almost impossible to establish, even approximately, according to the metric indicators we have.

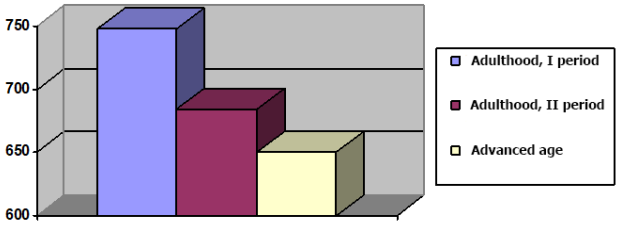

Fig. 2. Planimetric indices of the corpus callosum of men of three age periods (first and second periods of adulthood and advanced age)

Conclusions.

Despite the objective data we received, we still have to admit that at the present we do not have sufficient grounds to make a final conclusion about the beginning of involutive processes in corpus callosum at the above mentioned stage of development, which is considered to be stable in the development of the brain and the most productive in terms of intellectual development [5-7]. It is possible that such differences between planimetric indices of the corpus callosum of the first and second periods of mature age of men are explained by the quantitative insufficiency of the corresponding samples of anatomical preparations, as its dimensional parameters, as noted above, differ by a large individual scatter. And yet, if we consider in the general quantitative array of observations, including 65 preparations aged 22 to 73 years, there are some reasons to consider the existing general tendency to a slight decrease in corpus callosum of men approaching the advanced age.

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SUMMARY

PLANIMETRIC CHARACTERISTICS OF CORPUS CALLOSUM SAGITTAL PROFILE IN MIDDLE- AND ADVANCED AGED MEN

[1]Boiagina O., [2]Kostilenko Yu.

[1]Kharkiv National Medical University; [2]HSEIU "Ukrainian Medical Stomatological Academy", Ukraine

The sagittal profile of the corpus callosum is available for morphometric measurements of conditioned linear distances when elucidating its age-related changes and sexual dimorphism. But in this case, the opportunity to determine the total area of the sagittal profile of the corpus callosum is lost, while being a more full expression of its digital characteristics.

We set the goal to establish the differences between planimetric indices of male corpus callosum of the first and second periods of adulthood and the advanced age.

The work used 65 brain preparations of men aged 22 to 73 years who died for reasons unrelated to the pathology of the central nervous system. After a two-week fixation in a 10% solution of neutral formalin, the brain was dissected along the longitudinal sagittal fissure into two hemispheres, one of which was used to photograph its medial surface with an overlaid scale ruler. The received standardized photos were used to determine the basic metric parameters and conduct a planimetric study of the sagittal profile of the corpus callosum using the Adobe Photoshop CS6 Extended computer program.

The overall evaluation of the results of planimetric analysis of the male corpus callosum sagittal profile we directed attention to the fact that within each age group there is a wide scatter of individual digital values of its area as well as random and irregular nature of their distribution that is completely independent of the intra-group age chronology. Thus, in the first period of adulthood, the minimum value of the area of the corpus callosum sagittal profile is 560 mm^2, while the maximum value is 930 mm^2 (the average statistical value is 747.5 ± 110.4 mm^2). In the second period of adulthood, somewhat lower indicators are indicated; if the minimum value of it is equal to 412 mm^2, then the maximum value is 868 mm^2 (the average is 684.7 ± 130.0 mm^2). In the advanced age, we find them in the range between 441 and 867 mm^2 (the average value is 650.2 ± 121.9 mm^2), which is approximately comparable to the previous period and noticeably different from the value of the first period of adulthood.

At present, there is still no sufficient reason to draw a final conclusion about the beginning of involutive processes in the corpus callosum at the above stage of development, which is considered stable in the development of the brain and the most productive in terms of intellect. However, we can consider the existing general tendency to a slight decrease of the male corpus callosum when approaching the advanced age.

Keywords: corpus callosum, middle and advanced age, planimetric study.

РЕЗЮМЕ

ПЛАНИМЕТРИЧЕСКАЯ ХАРАКТЕРИСТИКА САГИТТАЛЬНОГО ПРОФИЛЯ МОЗОЛИСТОГО ТЕЛА МУЖЧИН В ЗРЕЛОМ И ПРЕКЛОННОМ ВОЗРАСТЕ

[1]Боягина О.Д., [2]Костиленко Ю.П.

[1]Харьковский национальный медицинский университет; [2]ВГУЗУ «Украинская медицинская стоматологическая академия», Украина

Сагиттальный профиль мозолистого тела доступен для проведения морфометрических измерений условных линейных дистанций при выяснении его возрастных изменений и полового диморфизма. При этом упускается возможность определения общей площади сагиттального профиля мозолистого тела, что является более полновесным выражением его цифровой характеристики.

Целью исследования явилось определить различия между планиметрическими показателями мозолистого тела мужчин первого, второго периодов зрелого возраста и пожилого возраста.

В работе использованы 65 препаратов головного мозга мужчин в возрасте от 22 до 73 лет, умерших по причинам, несвязанным с патологией центральной нервной системы. После двухнедельной фиксации в 10% растворе нейтрального формалина головной мозг рассекали по продольной сагиттальной щели на два полушария, одно из которых использовали для фотогра-

фирования его медиальной поверхности с наложенной масштабной линейкой. Полученные стандартизированные по формату фотоснимки служили для определения основных метрических параметров и проведения планиметрического исследования сагиттального профиля мозолистого тела с помощью компьютерной программы Adobe Photoshop CS6 Extended.

При общей оценке результатов планиметрического анализа сагиттального профиля мозолистого тела мужчин обращает внимание тот факт, что в пределах каждой возрастной группы наблюдается большой разброс индивидуальных цифровых значений его площади и беспорядочный, иррегулярный характер их распределения, который совершенно не зависит от внутригрупповой возрастной хронологии. Так, в первом периоде зрелого возраста минимальное значение площади сагиттального профиля мозолистого тела составило 560 мм^2, а максимальное – 930 мм^2 (среднестатистическое значение – 747,5±110,4 мм^2). Во втором периоде зрелого возраста выявлены сравнительно низкие показатели; если минимальное значение его оказывается равным 412 мм^2, то максимальное – 868 мм^2 (среднестатистическое – 684,7±130,0 мм^2). В преклонном возрасте они находятся в диапазоне между 441 и 867 мм^2 (среднестатистическое значение – 650,2±121,9 мм^2), что примерно сопоставимо с предыдущим периодом и заметно уступает первому периоду зрелого возраста.

В настоящее время еще нет достаточных оснований делать окончательный вывод о начале инволюционных процессов в мозолистом теле человека на вышеуказанном этапе развития, который считается стабильным в развитии головного мозга и наиболее продуктивным в интеллектуальном отношении. Однако все же можно судить о существующей общей тенденции к небольшому уменьшению мозолистого тела у мужчин с приближением к преклонному возрасту.

რეზიუმე

კორძიანი სხეულის საგიტალური კვეთის პლანიმეტრული მახასიათებლები მოზრდილი და ხანდაზმული ასაკის მამაკაცებში

[1]ო. ბოიაგინა, [2]იუ. კოსტილენკო

[1]ხარკოვის ეროვნული სამედიცინო უნივერსიტეტი; [2]უსსდ "უკრაინის სამედიცინო სტომატოლოგიური აკადემია", უკრაინა

კორძიანი სხეულის საგიტალური კვეთები მისაწვდომია პირობითი ხაზოვანი დისტანციის მორფომეტრუილი კვლევისთვის მისი ასაკობრივი და სქესობრივი დიმორფიზმის დადგენის მიზნით.

იმავდროულად, კორძიანი სხეულის საგიტალური კვეთის საერთო ფართობის განსაზღვრა ამ სტრუქტურის გაცილებით სრულფასოვან ციფრულ დახასიათებას იძლევა.

ნაშრომის მიზანს წარმოადგენს სხვადასხვა ასაკობრივ პერიოდში პირველი, მეორე მოზრდილობის და ხანდაზმულ ასაკში მამაკაცის კორძიანი სხეულის პლანიმეტრული მაჩვენებლების ასაკდამოკიდებული ძვრების განსაზღვრა.

კვლევის მასალას წარმოადგენს 65 პრეპარატი 22-73 წლის ასაკის მამაკაცის თავის ტვინიდან, რომელთა სიკვდილის მიზეზი არ იყო დაკავშირებული ცენტრალური ნერვული სისტემის პათოლოგიასთან, ნეიტრალური ფორმალინის 10% ხსნარში ფიქსაციის შემდეგ იკვეთებოდა ორი ჰემისფერო საგიტალური ნაპრალის მიხედვით, ერთი გამოიყენებოდა მასშტაბური სახაზავით მედიალური ზედაპირის ფოტოგრაფირებისთვის. სტანდარტული ფორმატის ფოტოსურათებზე განისაზღვრდა ძირითადი მეტრიული და პლანიმეტრიული პარამეტრები კომპიუტერული პროგრამის Adobe Photoshop CS6 Extended საშუალებით.

საგიტალური კვეთის ზოგიერთი პლანიმეტრიული კვლევის შედეგები მიუთითებენ, რომ ცალკეული ასაკობრივი ჯგუფის შიგნით არის მონაცემთა დიდი გაბნევა როგორც ფართობის, ასევე განაწილების ირეგულაციური ხასიათის მიხედვით, რომელიც სრულიად არ შეესაბამება ჯგუფებს შიგნით ასაკობრივ ქრონოლოგიას. ასე, მოზრდილთა I ასაკობრივ ჯგუფში კორძიანი სხეულის ფართობის მინიმალური სიდიდე არის 560 მმ^2, ხოლო მაქსიმალური - 930 მმ^2 (საშუალო სტატისტიკური – 747,5+130,0 მმ^2). II ასაკობრივი ჯგუფი ამავე პერიოდის რამდენადმე შემცირებული პარამეტრით ხასიათდება: მინიმუმ - 412 მმ^2 შეესაბამება, მაქსიმუმი – 868 მმ^2 (საშუალო სტატისტიკური კი – 684,7+130,0 მმ^2). ხანდაზმული ასაკობრივი ჯგუფის მონაცემები იმყოფება 441-867 ფარგლებში (საშუალო სტატისტიკური – 747,5+130,0 მმ^2). ფართობის დიაპაზონში (საშუალო არითმეტიკული – 650,2+121,9 მმ^2), რაც რამდენადმე შეეფარდება მოზრდილი ასაკობრივი ჯგუფის II პერიოდის მონაცემებს და ჩამორჩება ამავე პერიოდის I ჯგუფის მაჩვენებლებს.

სადღეისოდ არ არსებობს საკმარისი მტკიცებულებები კორძიანი სხეულის ინვოლუციის შესახებ ადამიანის განვითარების შესწავლილ პერიოდებში, რომელიც ითვლება თავის ტვინის განვითარების სტაბილურ და ინტელექტუალურად ყველაზე უფრო ნაყოფიერ ეტაპად, თუმცა შესაძლებელია მამაკაცის კორძიანი სხეულის საერთო მოცულობის შემცირების ასაკდამოკიდებულ ზოგად ტენდენციაზე მსჯელობა.