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## **Structural, stenotic changes and anatomical features of the cerebral vessels in patients with hypertension with low and medium level of total cardiovascular risk according to data of multidetector computed tomographic angiography**

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### **Abstract**

53 patients with arterial hypertension (AH) with low and medium level of total cardiovascular risk (TCR) were examined by using the 4-slice scanner and 128 slice scanner to detect the features of anatomical, structural and stenotic changes of cerebral vessels, according to multidetector computed tomographic (MDCT) angiography data. MDCT-semiotics of cerebral blood vessels changes in patients with hypertension manifested varying degrees of stenosis of the vertebral artery (VA). Frequent changes were seen in anterior (ACA), posterior cerebral (PCA) and the posterior communicating arteries (PcA), which usually manifest varying degrees of stenotic narrowing and sometimes tortuous course. Were widespread structural and stenotic changes of internal carotid artery (ICA). MDCT-angiography is a highly informative method to research the changes of the cerebral vessels in the patients with AH.

**Keywords:** MDCT-angiography, cerebral vessels, stenosis, hypertension, total cardiovascular risk.

### **1. Introduction**

Vascular brain disease is one of the most current problems of the modern cardiology and neurology considering a high prevalence of this pathology in the population as well as a rapid aging of the population<sup>[1]</sup>. Nowadays cerebrovascular disease in the structure of the mortality of the population of Ukraine occupies the second place following the ischemic disease of heart, at the same time in Europe and the USA it occupies the third place<sup>[1]</sup>. According to the statistics, mortality from cerebrovascular disease reaches 11-12% in the economically developed countries. During the last 10 years the prevalence of these diseases has increased by 1,6 times<sup>[2]</sup>. Multidetector computed tomography, in particular MDCT-angiography, is widely used in clinic. At present it is one of the most important methods of vascular diagnosis<sup>[3, 4, 5]</sup> and occupies one of the leading positions among the methods of imaging of cerebral blood vessels. Objective of this research work is to study the features of anatomical development and structural and stenotic cerebral vessels changes in patients with arterial hypertension with low and medium levels of total cardiovascular risk on the basis of MDCT-angiography data.

### **2. Material and Methods**

53 people aged between 20 and 64 underwent MDCT-angiography of the cerebral vessels. All these patients were divided into 2 groups. The main criterion of the division was the level of total cardiovascular risk which was determined by the SCORE model<sup>[6]</sup>.

The first group of the patients with the low level of total cardiovascular risk included 21 (13,91%) patients; 8 (38,1%) patients were male, 13 (61.9%) – female. The average age of the patients was 35,29±1,97 years old.

The second group of the patients with the medium level of total cardiovascular risk contained 32 (21,19%) people, 13 (40,63%) people were male and 19 (59,37%) - female. The average age of the patients of this group was 45,78±1,87 years old.

42 patients were examined by using the 4-slice scanner (Toshiba Asteion 4, Toshiba Medical System, Japan), and 11 patients were examined through 128 slice scanner (Siemens Definition AS+, Siemens Healthcare, Germany).

During the examination of the patients through the 4-slice scanner we used two methods of its realization: the protocol “Cerebral CTA” and the technique of CTA - tracking bolus (bolus-tracking) – “Cerebral CTA Sure Start” protocol.

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Depending on the area of research two protocols were used for the 128 –slice CT: “Neuro DSACT” and “Carotid DSACT”. During our research we used such iodine-containing contrast agents as iodixanol “Visipaque-320” and iopromide “Ultravist-370”, the volume of which depended on the type of CT and research protocols and ranged between 50-100 ml.

Data processing was performed on workstations VITREA and LEONARDO. The following indicants were estimated: course of major intracranial vessels such as the vertebral artery (VA), the basilar artery(BA), the anterior (ACA), middle (MCA) and posterior cerebral arteries (PCA), anterior (AcA) and posterior communicating arteries (PcA), segments of the internal carotid artery (ICA); their anatomical features [7]; innate characteristics of the course and branches; structural changes and the degree of artery stenosis that was calculated in the NASCET formula [8].

### 3. Results and discussion

Due to the MDCT – angiography of the cerebral vessels the diminution of the vertebral artery was visualized among the 11 (52,38%) patients with hypertension of the low level of total cardiovascular risk. 1 (4,76%) patient of this group had hemodynamic significant stenosis of the V4 segment of right VA with narrowing of the lumen of the artery by 54%. Hemodynamic not significant stenosis was visualized among the 6 (28,57%) patients: among 5 (23,81%) patients –stenosis on the level of V3-V4 segments of the right VA (fig.1.) and 1 (4,76%) patient –left VA. 4 (19,05%) patients had a normal anatomic variant of vertebral arteries: the dominance of the left VA was found among 3 (14,29%) patients and the dominance of the right VA – 1 (4,76%) patient.

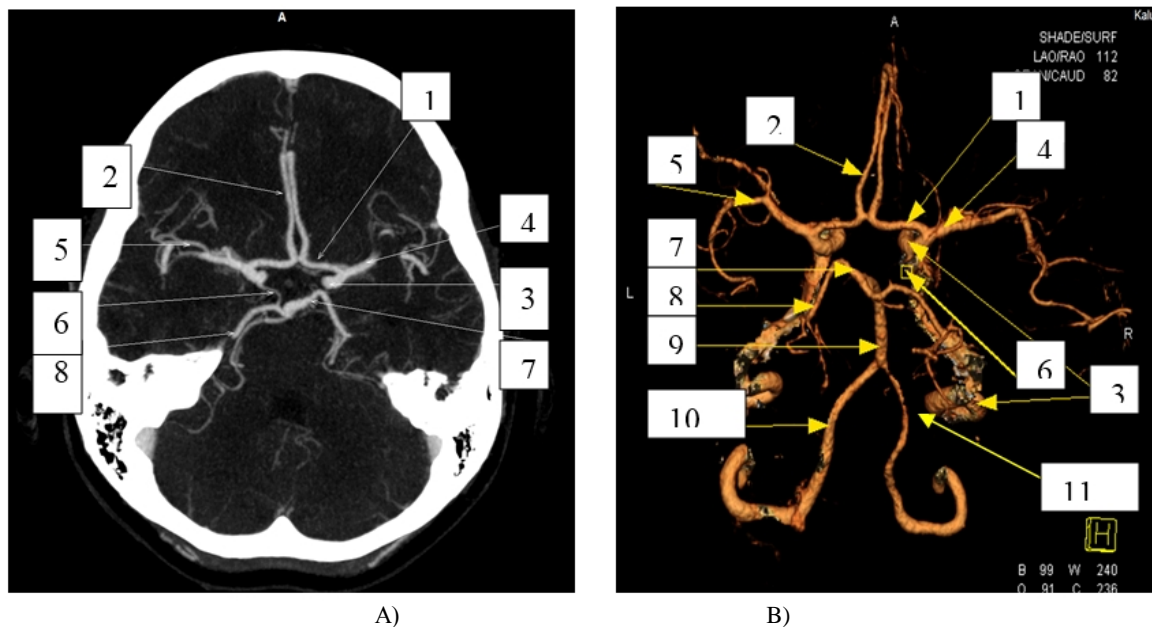
In frequency the second change of intracranial vessels was

hemodynamic not significant stenotic lesions of the posterior communicating artery: right - in 4 (19,05%) patients, the left - in 3 (14,29%). So the lumen of right PcA was reduced on average by  $23 \pm 4,45\%$ , and left - by  $31,5 \pm 2,63\%$ . Besides acquired changes of intracranial vessels we verified innate characteristics of the cerebral vessels, namely hypoplasia of PcA, which was found among 3 patients (14,29%) of the group, including the right PcA – 2 patients (9,52%) and left PcA – 1 patient (4,76%). Gemination of the posterior communicating arteries was found among 4 patients (19,05%), the changes of the right ones were seen among 2 patients (12,5%) and of the left – also 2 patients (12,5%). On the MDCT – images of 4 (19,05%) patients we verified aplasia of the PcA.

Changes of the ACA in this group of patients were noted in 6 (28,57%) cases. In 2 - (9,52%) patients hemodynamic not significant stenosis of ACA was registered: 1 (4,76%) patient had stenotic narrowing of the A1 segment of the left ACA by 24% and 1 (4,76%) man - A2 segment of the right ACA by 23,5%.

The variants of vascular anatomy such as aplasia and hypoplasia of A1 segment of the left ACA were found in the pictures of 2 (9,52%) patients of the group. One of the patients had the additional branch of the anterior cerebral artery, so called trifurcation of ACA, and another one had fenestration of A1 segment of the left ACA.

The structural changes of internal carotid arteries were frequent among the patients with hypertension of the low level of total cardiovascular risk. Sulcated course of the internal carotid arteries was registered among 3 (14,29%) patients. S-shaped deviation of the left ICA was visualized in 2 patient (9,52%) of the group.



**Fig 1:** MDCT – images of cerebral blood vessels of the patient G., 34 y.o. A) Axial MIP; B) 3D-reconstruction.

Conclusion: hemodynamic not significant stenosis of the right VA on the V4 segment, aplasia of left PcA: 1 - A1 segment of ACA; 2 - A2-A5 segments of ACA; 3 – ICA; 4 - M1 segment of MCA; 5 - M2 segment of MCA; 6 - right PcA; 7 - P1 segment of PCA; 8- P3 segment of PCA; 9 - BA; 10 – left VA; 11- stenosis of V4 segment of right VA

Hemodynamic not significant stenosis of ICA was visualized among the 3 (14,29%) patients: in 2 (9,52%) – right ICA was narrowed by  $18,6 \pm 5,03\%$  and in 1 (4,76%) patient –left ICA was narrowed by 21%. These changes better were seen on the

axial MDCT-images.

During the examination of the pictures of the patients of the second group with the hypertension of the medium level of total cardiovascular risk we found that intra-cerebral arteries

and neck arteries underwent changes under the influence of high blood pressure. The most common were:

- stenotic changes of the vertebral arteries, which were found among 10 (31.25%) patients of the group. Hemodynamic significant stenosis was found in 3 (9,38%) patients of the group. Hemodynamic not significant stenosis of the VA was verified in 7 (21,88%) patients of this group with narrowing of the lumen of right VA by  $23,18 \pm 3,45\%$  and the left one – by  $13 \pm 3\%$ .
- hemodynamic not significant stenosis of the posterior communicating arteries, which was found among 10 (31.25%) patients. 1 (3.13%) patients had hemodynamic significant stenosis of left PcA, so lumen was narrowed by 54%;
- hemodynamic not significant stenosis of anterior cerebral artery was visualized in 12 (37.5%) patients: in 8 (25%) the lumen of the right ACA was narrowed by

$27,37 \pm 5,19\%$  and in 4 (12.5%) patients – the left by  $34,75 \pm 4,15\%$ . 1 (3.13%) patients had hemodynamic significant stenosis of left ACA, so lumen was narrowed by 60%. MDCT-semiotics of stenotic and structural changes of cerebral vessels in patients with hypertension with low and medium level of total cardiovascular risk are shown in table 1.

- Hemodynamic not significant stenosis of internal carotid arteries was visualized among 5 (15,63%) patients with hypertension with medium TCR, moreover, in 4 cases (12,5%) the right ICA was diminished, and in 1 case (3,13%) – the left one. As a rule the diminution was noticed on the level of C1 neck segment, but in some cases the diminution on the level of C3-C4 segments of ICA was registered

**Table 1:** MDCT-semiotics of stenotic and structural changes of cerebral vessels in patients with hypertension with low and medium level of total cardiovascular risk

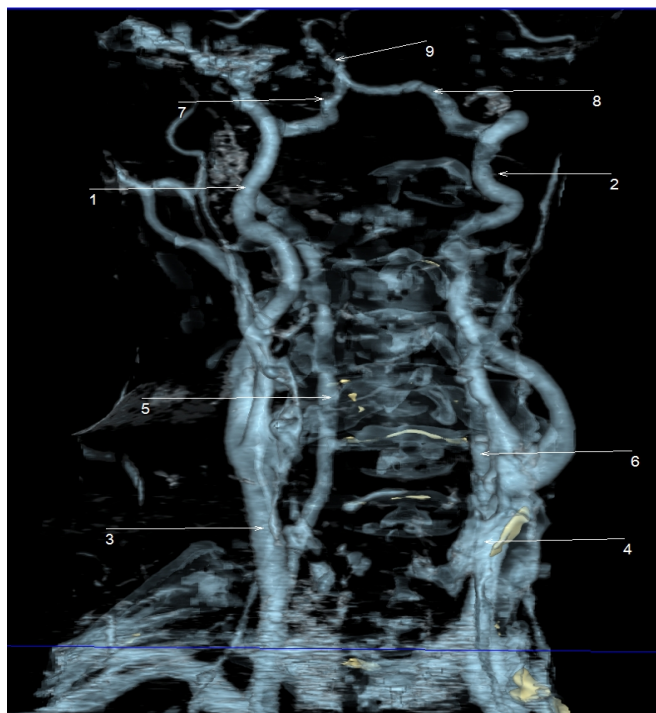
| MDCT-semiotics                                            | Patients with hypertension with low TCR n=21 |     | Patients with hypertension with medium TCR n=32 |      |
|-----------------------------------------------------------|----------------------------------------------|-----|-------------------------------------------------|------|
|                                                           | abs                                          | %   | Abs.                                            | %    |
| Hemodynamic not significant stenosis of VA                | 6                                            | 5,2 | 7                                               | 6,1  |
| Hemodynamic significant stenosis of V1 segment of VA      | -                                            |     | 2                                               | 1,7  |
| Hemodynamic significant stenosis of V4 segment of VA      | 1                                            | 0,9 | 1                                               | 0,9  |
| Coiling of VA                                             | -                                            |     | 1                                               | 0,9  |
| Hemodynamic not significant stenosis of ICA               | 3                                            | 2,6 | 5                                               | 4,3  |
| Hemodynamic significant stenosis of ICA                   | -                                            |     | 1                                               | 0,9  |
| Deviation of ICA: tortuosity of ICA                       | 3                                            | 2,6 | 5                                               | 4,3  |
| S-shaped deviation of ICA                                 | 2                                            | 1,7 | 2                                               | 1,7  |
| Hemodynamic not significant stenosis of PcA               | 7                                            | 6,1 | 10                                              | 8,7  |
| Hemodynamic significant stenosis of PcA                   | -                                            |     | 1                                               | 0,9  |
| Hemodynamic not significant stenosis of ACA               | 3                                            | 2,6 | 12                                              | 10,4 |
| Hemodynamic significant stenosis of ACA                   | -                                            |     | 1                                               | 0,9  |
| Hemodynamic not significant stenosis of P1 segment of PCA | 3                                            | 2,6 | 7                                               | 6,1  |

- Structural changes of the internal carotid artery such as tortuosity at the level of the neck was found among 7 (21,88%) patients. The changes of the right ICA was found in 1 patient (2%), left – 3 (9,38%), and the tortuosity of both ICA was found among 3 patients (9,38%). S-shaped deviation of the internal carotid artery at the level of the neck was found among 2 (6,25%) patients ( fig. 2.).

Besides acquired changes of intracranial vessels we verified innate characteristics of the cerebral vessels, namely dominance of the left VA was found in 10 (31.25%) patients. Aplasia of PcA was seen in 3 (9,38%) patients. Hypoplasia of PcA was found among 2 (6,25%) patients of the group. Aplasia of A1 segment of the left ACA was found in the

pictures of one patient (3,13%) of the group. 2 (6,25%) patients had the additional branch of the anterior cerebral artery, so called trifurcation of ACA, and 1 (3,13%) patient had fenestration of A1 segment of the left ACA. MDCT-characteristic of anatomical features of the brain vessels in patients with hypertension with low and medium level of total cardiovascular risk are shown in table 2.

MDCT-semiotics of cerebral blood vessels changes in patients with hypertension manifested varying degrees of stenosis of the vertebral artery. Frequent changes were seen in anterior, posterior cerebral and the posterior communicating arteries, which usually manifest varying degrees of stenotic narrowing and sometimes tortuous course. Were widespread structural and stenotic changes of internal carotid artery (ICA).



**Fig 2:** 3D-reconstruction of the cerebral vessels of the patient Y., 55 y.o. Conclusion: S-shaped deviation of both internal carotid arteries on the level of C1 segment: 1 - C1 segment of right ICA; 2 - C1 segment of left ICA; 3 – right common carotid artery; 4 – left common carotid artery; 5 – right VA; 6 – left VA; 7 - V4 segment of right VA; 8 - V4 segment of left VA; 9 - BA

**Table 2:** MDCT- characteristic of anatomical features of the brain vessels in patients with hypertension with low and medium level of total cardiovascular risk

| MDCT-semiotics                    | Patients with hypertension with low TCR<br>n=21 |     | Patients with hypertension with medium TCR<br>n=32 |     |
|-----------------------------------|-------------------------------------------------|-----|----------------------------------------------------|-----|
|                                   | Abs.                                            | %   | Abs.                                               | %   |
| Aplasia of A1 segment of ACA      | 1                                               | 0,9 | 1                                                  | 0,9 |
| Hypoplasia of A1 segment of ACA   | 1                                               | 0,9 | -                                                  |     |
| Trifurcation of ACA               | 1                                               | 0,9 | 2                                                  | 1,7 |
| Fenestration of A1 segment of ACA | 1                                               | 0,9 | 1                                                  | 0,9 |
| Aplasia of PcA                    | 4                                               | 3,5 | 5                                                  | 4,3 |
| Hypoplasia of PcA                 | 3                                               | 2,6 | 4                                                  | 3,5 |
| Gemination of PcA                 | 4                                               | 3,5 | -                                                  |     |
| Hypoplasia of P1 segment of PCA   | 2                                               | 1,7 | -                                                  |     |
| Dominance of VA                   | 4                                               | 3,5 | 10                                                 | 8,7 |

**4. Conclusion**

MDCT- angiography allowed us to visualize anatomical features of the brain vessels, such as aplasia, hypoplasia, germination or dominating of blood vessels and to diagnose structural and stenotic changes of cerebral vessels in patients with hypertension of low and medium level of total cardiovascular risk. MDCT- angiography showed highly informative to research all these changes of the cerebral vessels.

The vertebral arteries, anterior and posterior cerebral arteries, posterior communicating arteries often underwent changes that, as a rule, showed their varying degrees of stenosis and structural changes.

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