Evaluation of changes in the parameters of brain tissue perfusion in multi-slice computed tomography in patients after carotid artery stenting

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Summary

Background: CT perfusion of the brain allows functional evaluation of cerebral blood flow. Patients with chronic internal carotid artery (ICA) stenosis may suffer from malperfusion. Improvement of cerebral blood flow and remission of neurological symptoms indicate the effectiveness of treatment of internal carotid artery stenosis.

Material/Methods: The aim of the study was to analyze alterations within cerebral perfusion parameters in CT brain perfusion examination in patients who were scheduled for endovascular therapy due to ICA stenosis. Forty patients with ICA stenosis of over 79% who were included in this prospective study underwent perfusion CT examination twice – 24 hours prior to stenting and after 6–8 weeks following the procedure. CBF, CBV, MTT and TTP were evaluated.

Results: Prior to endovascular therapy, an increase in MTT and TTP, and a decrease in CBV and CBF were observed within arterial supply of the hemisphere ipsilateral to stenosis. After the procedure, a decrease in MTT and TTP was seen in all cases, while no statistically significant changes of CBF or CBV were observed. MTT proved to be the most sensitive indicator of ICA stenosis, as its values allowed differentiation between critical and non-critical stenosis. No correlation between the degree of ICA stenosis and TTP values was found. Mild cerebral hyperperfusion syndrome (CHS) was observed in only one patient and the difference between pre-treatment MTT values calculated for both hemispheres was shown to be a prognostic factor for CHS incidence.

Conclusions: Endovascular stent placing in patients with hemodynamically significant internal carotid artery stenosis results in alteration of perfusion parameters, especially concerning TTP and MTT.

Key words: CT brain perfusion • stent • CBV • BCF • TTP • MTT • cerebral hyperperfusion syndrome (CHS)

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Background

In 1980s, radiology developed a new neuroimaging technique called perfusion computed tomography (p-CT). This technique is based on the variable linear attenuation coefficient of brain tissue after intravenous or (rarely) inhaled contrast media administration. This method allows the functional assessment of cerebral blood flow. Modern computer software allows to process data obtained during the examination in such a manner that only the first contrast passage is imaged, which results in a significant reduction of the contrast agent volume to be given.

Measurements of the attenuation coefficient in large cerebral vessels provide a quantitative assessment of parameters such as the Cerebral Blood Volume (CBV) in the area of interest, Cerebral Blood Flow (CBF), Mean Transit Time (MTT) and Time To Peak (TTP). All of these parameters are
presented as color maps of parametric perfusion images, or quantified within ROI (Region Of Interest).

The cerebral blood flow improvement and the resolution of the neurologic symptoms are the exponents of treatment efficacy in carotid artery stenosis. Measurements of cerebral perfusion parameters may be useful to evaluate changes in cerebral circulation after endovascular stent implantation. The aim of this study was to analyze changes in brain tissue perfusion evaluated with cerebral perfusion CT after recanalization of cerebral vessel stenosis.

Material and Methods

A brain perfusion CT in 20 consecutive patients (10 women and 10 men, aged 53–80 years, mean age of 66.5 years) treated for internal carotid artery stenosis was performed at the Department of Radiology, Medical University of Gdansk in 2008–2010. Patients with unilateral stenosis of the internal carotid artery of more than 79% and coexistent clinical neurological symptoms such as TIA (11 patients), past ischemic stroke (8 patients) and seizure incident (1 person) were included.

Patients with right internal carotid artery stenosis (RICA) accounted for 65% of the entire cohort (n=13), and those with stenosis within the left internal carotid artery (LICA) accounted for 35% of the study group (n=7). In addition, patients were divided into two groups. The first included patients with stenosis of 79–89%, which is a non-critical stenosis (n=9), and the second included patients with stenosis of more than 90% – a critical narrowing (n=11). Stenosis was diagnosed in most of the cases based on Doppler examination. Less often (in doubtful cases) based on CT angiography or CAS (Figure 1).

The exclusion criteria of stent implantation were as follows: asymptomatic, hemodynamically insignificant stenosis of internal carotid artery or bilateral hemodynamically significant stenosis within carotid arteries. Each patient was subjected to brain perfusion CT, twice. The first examination was performed prior to stent implantation (up to 24 hours before the scheduled surgery), the second, 4–8 weeks after implantation. Each perfusion CT was preceded by CT examination without contrast agent administration in order to exclude signs of recent hemorrhage or ischemia or features of increased intracranial pressure. Perfusion CT was performed using GE Lightspeed 64 VCT with 40 ml of intravenous iodinated low-osmolarity contrast agent (with a bolus of 40 ml of saline after the injection) injected at the rate of 4 ml/s; the area of the brain under examination was 80 mm (5-mm slices), which resulted in 16 levels to be measured.

Rotation time – 0.4 sec, detector configuration: 64×0.625 mm, total scan time – 46.6 sec., total exposure time – 13.6 sec, 500 mAs, 80 kV, SFOV-32, time resolution of 1/sec. The assessment of perfusion parameters was carried out from the level of pons to the upper parts of cerebral hemispheres included in the examination, in the area supplied by the middle cerebral artery (MCA). Using CT perfusion 4 applications (GE company) – Brain Stroke Protocol, perfusion parameters in each of the sixteen brain layers included in the examination were processed. The assessment covered:

– Mean Transit Time (MTT),
– regional Cerebral Blood Flow (rCBF),
– regional Cerebral Blood Volume (rCBV),
– Time to Peak (TTP). Stent implantation treatments within narrowed internal carotid arteries (ICA) were performed under local anesthesia (1% Lignocainum) using the Seldinger method (common femoral artery puncture). Each test was preceded by diagnostic arteriography for a final confirmation of the presence, size and exact location of the stenosis. Subsequently (after placing the cerebral protection system), stent implantation procedures were
performed within the stenosis. Two types of stents were used: ACCULINK and X-act.

Immediately after surgery, a selective, control arteriography was performed in order to confirm the correct location of the stent, and correct blood flow in enlarged blood vessel (Figure 2).

**Results**

The main purpose of the statistical analysis was to evaluate changes in perfusion parameters in the MCA supply area in patients with stenosis within one of the internal carotid arteries after endovascular stent implantation.

The basis of the analysis was descriptive statistics: means and standard deviations, and percentage values of parameters. The following standard parameters of perfusion studies were analyzed: MTT, CBV, CBF and TTP. The primary statistical tool used for analyzing the differences between mean values was the analysis of variance (ANOVA). This tool was used, first of all, to check whether the values before and after stenting were significantly different, and second of all, whether this difference correlated with the degree of artery stenosis. Analysis of variance (ANOVA) allowed to obtain three types of effects:

1. main effect of the repeated measures factor, which is finding a statistically significant difference between the perfusion parameters before and after stenting,
2. main effect of the factor of stenosis degree (critical vs. non-critical stenosis),
3. interaction effect, which indicates whether the difference between values of each perfusion parameter depends on the degree of artery stenosis (i.e. whether there are differences in perfusion depending on the degree of vessel stenosis) – statistical significance of the effect is illustrated by the value and significance of F statistics.

In addition, for each value of F test, an effect size estimator was calculated – partial eta-square ($\eta^2$), that is standardized mean difference. It was assumed that $\eta^2=0.1$ stands for a small effect, $\eta^2=0.25$ – medium effect and $\eta^2=0.50$ – large effect.

In case of statistically significant interaction effect, a standard significance test was used, i.e. the Student’s t-test.

Additionally, for each t-test value, Cohen’s d was calculated.

Cohen’s d estimates the effect size, giving the actual significance of mean difference being analyzed. It was assumed that $d>0.20$ indicates a small effect (non-significant difference); $d>0.50$ refers to a medium effect; $d>0.80$ points to a large effect (large difference between means).

D statistics allows the comparison between different parameters obtained in perfusion examination. Thanks to that, one can demonstrate, which of the assessed parameters of brain perfusion is the most sensitive in response to stent implantation.

The nominal alpha criterion level was set at 0.05. The difference was considered significant only when obtained in the test at P value of less than the nominal criterion level (i.e. P<0.05).

Correlations between variables were analyzed using Pearson’s correlation coefficient. It was assumed that correlation value of approximately 0.20 means low stability; 0.60 – medium stability; and 0.80 – high stability of measurement.

The data were described using arithmetic mean (M), standard deviation (SD), confidence intervals (95%), standard error of the mean (SEM). The normality of the distribution was also determined for all the variables using the z-test (Kolmogorov-Smirnov test).

Analysis was performed on a full set of raw data. Sixteen measurements of each perfusion parameter were obtained for each patient, giving 360 measure points for whole group of 20 patients.

This method of data analysis allowed the use of detailed data, creating circumstances for a very thorough statistical analysis.

At the beginning of data analysis, a normality of distribution was determined.

Consecutively, the analysis of differences between mean results obtained in measurements of perfusion parameters in affected and non-affected hemispheres before stenting, as well as the temporal stability of measurements, was conducted.

The next stage was the comparison of changes in perfusion parameters values of the ipsilateral hemisphere within the middle cerebral artery (MCA) supply area after stenting.

Finally, it was established, to what extent the size of stenosis of the internal carotid artery correlated with perfusion parameters.

**Normality of variable distribution**

The analysis of distribution normality of the assessed perfusion parameters was performed using the Kolmogorov-Smirnov test. Only some of the parameters showed a normal distribution. It did not affect the choice of statistical tests, since, as shown by Monte Carlo analysis (reliability of statistical tests), the lack of normal distribution does not restrict the use of parametric tests of difference significance or associations between variables [1].

Table 1 contains the results of the K-S test along with interpretation. It shows that the violation of assumptions on normality appeared for most of variable distributions, especially pronounced in case of the TTP parameter.

**Differences in perfusion parameters within both cerebral hemispheres before stenting**

At this stage of analysis, the differences between both hemispheres before stent implantation were examined (i.e.
the hemisphere supplied by affected blood vessel – ipsilateral hemisphere, and hemisphere supplied by unaffected artery). The analysis was performed using a mixed-model, two-way analysis of variance (ANOVA), where the first factor was the repeated measurement of perfusion parameter, and the second was the degree of stenosis (critical and non-critical stenosis). At the beginning, ANOVA was performed for the MTT parameter. The analysis revealed only the effect of size of stenosis. MTT parameter value in the group of patients with critical narrowing was significantly higher than in the group with non-critical stenosis (M=10.19, SD=1.13, M=9.15, SD=0.92), F (1,318)=42.01, P<0.001, MSE=.074, η²=0.12; respectively). Other effects were not statistically significant (F<1).

Another ANOVA analysis was performed for CBV parameter. No significant effects were revealed – the measurement means were not significantly different. The next analysis, performed for rCBF parameter revealed only a significant interaction effect between the factors of low power (F (1,318)=4.58, P<0.05, MSE=0.482, η²=0.01). As a consequence of significant interaction, a series of tests was performed to detect the sources of interaction. It was found that patients with critical stenosis within the ICA showed higher values of CBF of the ipsilateral (affected) hemisphere than those without such a severe stenosis (t (318)=2.05, P<0.05, d=0.19). Moreover, it was revealed that in a group of patients with non-critical stenosis, the mean CBF values were lower within the affected hemisphere comparing to the non-affected one (t (143)=4.29, p<0.05, d=0.20).

Mean values are presented in Table 2. The last ANOVA was performed for TTP parameter. It revealed the main effect of repeated measurement of low power. It turned out that the mean value of this perfusion parameter for the affected hemisphere was lower than for the unaffected one (M=25.93, SD=3.51, F=26.11, P<0.001, MSE=0.195, η²=0.05, respectively) Other effects were not statistically significant (F<1).

Summarizing the above analysis, it is clear that differences detected between the mean values of perfusion parameters before stenting are minor, as indicated by the low or negligible effect size calculated using a standardized mean difference η2 and Cohen’s d. Hence, it should be concluded that the group of examined patients was homogeneous.

### Table 1. Normality of distribution of perfusion parameters (K-S test, Z statistics) before and after stenting, N=20.

| Parameter, time | Z-statistics | Normality of distribution |
|----------------|--------------|---------------------------|
| MTT Before stenting | 1.29 | Yes |
| After stenting | 1.02 | Yes |
| CBV Before stenting | 1.78** | No |
| After stenting | 0.94 | Yes |
| CBF Before stenting | 1.89** | No |
| After stenting | 1.48* | No |
| TTP Before stenting | 2.55*** | No |
| After stenting | 2.49*** | No |

* P<0.05; ** P<0.01; *** P<0.001. Statistics free of marks is not significant.

### Table 2. Statistics for perfusion parameters before stenting, depending on the degree of stenosis, N=20.

| Type of stenosis, parameter | Affected hemisphere (cause of referral) | Unaffected hemisphere |
|-----------------------------|----------------------------------------|-----------------------|
|                            | Descriptive statistics | Confidence interval (95%) | Descriptive statistics | Confidence interval (95%) |
|                            | M a | SD b | Lower | Upper | M | SD | Lower | Upper |
| MTT Critical (n=11) | 10.24 | 1.13 | 10.24 | 10.40 | 10.14 | 1.14 | 9.97 | 10.31 |
| CBV | 2.11 | 0.57 | 2.02 | 2.19 | 2.14 | 0.69 | 2.04 | 2.25 |
| CBF | 21.65 | 7.03 | 20.61 | 22.70 | 21.19 | 6.07 | 20.19 | 22.19 |
| TTP | 25.63 | 3.18 | 25.16 | 26.11 | 25.72 | 3.11 | 25.33 | 26.25 |
| MTT Non-critical (n=9) | 9.50 | 0.95 | 9.35 | 9.66 | 9.52 | 0.83 | 9.38 | 9.66 |
| CBV | 1.99 | 0.48 | 1.92 | 2.08 | 2.03 | 0.52 | 1.95 | 2.12 |
| CBF | 20.20 | 5.33 | 1.32 | 21.08 | 2.03 | 0.39 | 1.97 | 2.10 |
| TTP | 26.24 | 3.88 | 2.60 | 26.88 | 26.54 | 3.84 | 25.91 | 27.17 |

a M – arithmetic mean; b SD – standard deviation; c number of measurements was 176, so the number of degrees of freedom (df) was 175; d number of measurements was 143, so the number of degrees of freedom (df) was 143. The total number of degrees of freedom was 318.
Temporal stability of the measurements of perfusion parameters

The aim of this study was to examine the extent to which the enlargement of the internal carotid artery (ICA) would affect the stability of measurements of perfusion parameters.

For the data calculated on the entire sample, in case of MTT parameter, a low stability, \( r=0.25, \) was obtained. Similarly, CBV showed a low stability, with \( r=0.17, \) as well as CBF, with \( r=0.29. \) The TTP parameter on the other hand revealed the highest stability of measurements – \( r=0.73. \)

Assessment of changes in perfusion parameters of the cerebral hemispheres after stenting implantation

The analysis of changes in perfusion parameters was based on data obtained from the area of the MCA basin supplied by stenotic arteries, after stent implantation.

Figure 3 contains the percentages for these parameters. These data determine the ratio calculated basing on the values of perfusion parameters within affected hemisphere before and after stenting (statistic presented Table 3).

For each perfusion parameter, the percentage value before and after stenting was compared. Not for all parameters the statistically significant differences were obtained: MTT: \( t (19)=1.78, P<0.05, d=0.34. \) CBV – no statistically significant difference: \( t (19)=0.93, \) ni, \( d=0.19. \) CBF – no statistically significant difference: \( t (19)=1.27, \) ni, \( d=0.28.. \) while TTP – statistical significance: \( t (19)=3.65, P<0.01, d=0.82. \)

Expected change in perfusion parameters was observed only in case of MTT and TTP (decrease of value after stenting).

The correlation between size of stenosis within ICA and perfusion parameters after stent implantation

The aim of this analysis was to determine whether there are differences in perfusion parameters within the cerebral hemispheres after surgery of internal carotid artery widening and the size of stenosis within that artery (critical vs. non-critical stenosis). The comparison was based on ROC procedure. Classification variable was the type of stenosis, and the variable used for comparison was the index of difference between the percentage values of perfusion within the MCA supply area (see Figure 3).

The ROC values calculated for MTT and TTP were used, as only for these parameters the expected changes were observed (decrease in parameters values after stent implantation).

The ROC analysis was presented in Table 4. It shows that only MTT differentiates the groups with critical and non-critical stenosis. Mean value of difference coefficient for MTT parameter in the group with critical stenosis was 5.12 (SD=1.83), and for the non-critical stenosis group, 1.60 (SD=1.95), where the mean value below zero indicates that the percentage value of the MTT parameter before stenting was lower than after stenting. It should be emphasized that only values above zero, regarding stent implantation, are desired, as they indicate the decrease of perfusion parameter values resulting from surgery procedure. For the MTT parameter, the desired effect after stenting occurred only in patients with critical stenosis.

The value of the difference coefficient TTP for patients with critical stenosis within ICA was 8.10 (SD=9.30) and for patients with non-critical stenosis, 5.65 (SD=7.63). Each of these values differed significantly from zero (\( t \)\( >1.96 \) \( d \geq 0.50 \)), which means that in each group, an expected change in perfusion parameter was observed (i.e., decrease after stenting). Then, it was determined, which

![Figure 3](image-url)
of the analyzed parameters allows the best differentiation between the two compared groups.

It turned out that the MTT did not differentiate better than TTP ($z=0.70$, $\text{AUC}_{\text{MTT}}-\text{AUC}_{\text{TTP}}=0.14$) – Figure 4 and Table 4.

In conclusion, although none of the parameters showed better differentiating value, the only indicator that allowed the detection of a statistically significant difference between groups with critical and non-critical stenosis was the MTT parameter.

**Discussion**

Stroke is currently the third most common (after cancer and heart disease) cause of death. It has been estimated that one in ten European people over 50 years of age and every second over 70 dies of this reason [2,3]. Clotting material from unstable sclerotic plaques located within narrowed internal carotid arteries is a cause of approximately 20% of all ischemic strokes [4–6]. The enlargement of a narrowed cerebral blood vessel in patients with stenosis of $\geq 70\%$, and with additional neurological symptoms, reduces the absolute five-year risk of ischemic stroke by 16% [7].

The presence of a hemorrhagic or ischemic focus in the cerebrum and the identification of the phase of its evolution determines the clinician’s decision on stent implantation into the vessel with stenosis. Revealing an acute ischemic focus postpones the procedure by about 6–8 weeks [5].

Hence, a thorough assessment of brain tissue is essential before implementation of procedures increasing the arterial blood flow into the brain.

Perfusion CT (p-CT) provides that kind of information. This method enables a precise quantitative or semi-quantitative evaluation of blood flow per unit of time in a particular region. In contrast to the conventional CT, this method determines in which area of brain tissue changes are irreversible and in which the ischemia may be transient.

According to Ezzeddine et al., perfusion CT remains more sensitive (100%) and specific (92%) than the conventional CT (sensitivity of 93% and specificity of 67%) in revealing acute ischemic changes [8,9].

There are two methods of performing perfusion CT: with an inhaled contrast agent (stable xenon) or an intravenous iodinated contrast agent. In our study, the second technique was used.

The primary aim of the study was to evaluate changes in brain tissue blood supply in patients undergoing stent implantation into the narrowed internal carotid artery. The question was, which of the evaluated parameters of perfusion CT is the most sensitive indicator of the above-mentioned changes, useful in predicting potential changes in perfusion (depending on the degree of stenosis within ICA) and helping to select patients at risk of cerebral hyperperfusion syndrome (CHS) after vessel widening.

CBF, CBV, MTT and TTP were taken into account (Figure 5). Each of these parameters describes changes in blood supply within the analyzed brain tissue in a different way, as presented below:

**Regional Cerebral Blood Flow (rCBF)** is calculated and displayed in ml per 100 g of brain tissue (wet weigh) per minute and refers to the amount of blood flow in a certain region. The reference value for gray matter is about...
Time was calculated as the initial height of the IRF divided by the enclosed area (IRF T0).

In normal conditions, MTT values oscillate between 3 and 5 seconds.

**Time-To-Peak (TTP)** means time between transient enhancement (last image before contrast enhancement) and the peak of the time curve (image with the maximum value preceding the first image after enhancement). TTP value depends on many parameters, including: cardiac output or the degree of stenosis of a vessel leading to brain.

In all of our patients, p-CT performed before stent implantation revealed a prolongation of MTT and TTP with a decrease of CBV and CBF values within the cerebral hemispheres supplied by the internal carotid artery (ICA) with stenosis. This data were consistent with reports by other authors [5,7,13] – Table 3.

After surgery, only MTT and TTP parameters changed in a predictable way, i.e. their values were reduced in all the cases. Conversely, CBF and CBV did not change as it was expected (no increase).

The value of this parameter decreases by 0.45% per each year of life. In also decreases in proportion to the degree of stenosis of the vessel supplying the cerebral hemisphere [10–12].

**Regional Cerebral Blood Volume (rCBV)** is calculated and displayed in ml per 100 g of brain tissue (wet weight) and refers to the volume of blood remaining in microcirculation. Blood volume is equal the blood flow multiplied by mean transit time.CBV=CBF×MTT. The reference value for gray matter is about 5–6 ml/100 g, and for white matter: 2–3 ml/100 g. The increase in that parameter indicates impaired autoregulation in ischemic brain tissue.

**Mean Transit Time (MTT)** is calculated and displayed in seconds. The MTT characterizes the average time period in which the contrast agent remains within the brain tissue, reflecting indirectly the local perfusion pressure.

In mathematical terms, the mean transit time is evaluated as the first time value of remaining impulse function in relation to the time of activation of IRF (T0). Mean transit time was calculated as the initial height of the IRF divided by the enclosed area (IRF T0).

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After surgery, only MTT and TTP parameters changed in a predictable way, i.e. their values were reduced in all the cases. Conversely, CBF and CBV did not change as it was expected (no increase).
We believe that this could be the result of a long-term deficit in brain perfusion caused by stenosis of one of the internal carotid arteries, leading to abnormal autoregulation at the level of intracerebral vessels. It was confirmed in small differences between CBF and CBV values before and after surgery.

According to Hunter et al. and Esteban et al., CBV is the best marker of disorders of autoregulation within the cerebral blood vessels, since its correct value depends on the number, caliber and ability to adopt the diameter depending on the disturbances in blood flow [10,11].

To confirm an impaired autoregulation, some researchers suggest performing a test with intravenous acetazolamide [5,14].

In our patients, we did not perform this test assuming that a long-term stenosis of cerebral vessels and a long history of clinical manifestations of cerebral circulatory deficit authorizes the hypothesis of irreversibly impaired autoregulation.

Many researchers argue that MTT and TTP are the most sensitive parameters of brain perfusion alterations [5,10–12].

This was confirmed in our study. Simultaneously, our study demonstrated that TTP is a more sensitive marker of perfusion changes, which was confirmed by Cohen’s d values – effect size for TTP was more than twice the value of MTT (see results).

In papers published so far, CBF and TTP are considered the most sensitive indicators of the degree of ICA stenosis [5,10–12].

In presented analysis, after rejection of CBF parameter (since it did not meet the assumption of post-stenting increase), MTT was acknowledged the most sensitive marker of stenosis, as its values (in the study group) differentiated patients with critical and non-critical stenosis. On the other hand, TTP appeared to be independent from the degree of stenosis, i.e. the stenosis did not affect its values.

The most possible explanation is that TTP values do not depend solely on the degree of stenosis within the ICA, but also result from functional capacity of the circle of Willis, cardiac output or method of contrast agent administration [5,15].

Approximately 5% of patients after recanalization of an extracerebral vessel, hyperperfusion syndrome (CHS) occurs [5,14,16]. Hyperperfusion syndrome (CHS) is a consequence of a rapid improvement of blood flow (e.g., after stent implantation or endarterectomy) in blood vessel with prior prolonged stenosis.

The longer the duration of stenosis, the greater is the risk of hyperperfusion [14,16,17]. Symptoms of this syndrome occur within a week after the procedure and manifest as hemiorganic headaches, as well as orbital and facial pain. Some patients may experience seizures or migraine [5,14,16,17]. The most serious consequence of hyperperfusion syndrome is intracranial bleeding with mortality reaching even 40% [18].

In the study group, 1 patient (5%) developed hyperperfusion syndrome of mild intensity, manifested as headaches and orbital pain, which was consistent with other reports [14,16]. We found no intracranial bleeding as a result of stent implantation.

It seems that a good predictor of CHS is the difference in MTT values between the two hemispheres before stenting. This hypothesis is consistent with the opinion by Tseng et al., claiming that the absolute difference in MTT values between the cerebral hemispheres of more than 3 seconds predisposes to this syndrome [16].

In our group, the patient with the greatest difference in MTT values before stenting the critical stenosis was the one, who manifested CHS. On the other hand, according to Fukuda’y et al., the initially high CBV values increase the risk of hyperperfusion syndrome after widening of the carotid artery [19]. In our material, no such a correlation was found.

In conclusion, it has to be stated that brain perfusion CT can be performed using any multi-slice CT scanner, which makes this method widely available and relatively cheap. This complements patients’ assessment and qualification for carotid artery recanalization, improving outcomes of treatment.

Conclusions

Endovascular stent implantation in patients with hemodynamically significant internal carotid artery stenosis results in a measurable change in the parameters of brain tissue perfusion, including especially TTP and MTT. Perfusion CT performed before stent implantation helps to predict the degree of improvement of brain tissue blood supply after procedure and select a group of patients with a potentially higher risk of hyperperfusion syndrome.

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