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FULL PAPER

Perfusion computed tomography: 4 cm versus 8 cm coverage size in subjects with chronic carotid artery stenosis

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Objective: The impact of coverage size on global cerebral blood flow (CBF), cerebral blood volume (CBV), mean transit time (MTT) and time to peak (TTP) parameters has not been investigated in patients with chronic carotid artery stenosis.

Methods: 63 patients with stenosis of >70% within a single internal carotid artery and neurological symptoms were randomly assigned to two well-matched groups. Differences in CT perfusion scan over a 4 cm or 8 cm range of the brain were compared between the two groups.

Results: The CBF and CBV values were higher in the 4 cm coverage size than in the 8 cm coverage size (by 14.7 and 10.7% on the ipsilateral side and 17.2 and 7.8% on the contralateral side, respectively; all $p < 0.001$). The MTT value was higher in the 4 cm coverage size than in the 8 cm coverage size on the ipsilateral side (9.6%; $p < 0.001$). There was no

difference between MTT values in the contralateral size. There were no differences between TTP values on the ipsilateral and contralateral sides. The relative indices rMTT and rTTP were higher in the 4 cm coverage size than in the 8 cm coverage size (8.2%, $p < 0.001$, and 1.1%, $p < 0.005$, respectively).

Conclusion: Absolute CBF and CBV values and relative rMTT and rTTP indices in patients with low CBF and low CBV are highly dependent on coverage size. We recommend using a 4 cm coverage size to assess global cerebral perfusion parameters owing to better accuracy and quicker post-processing.

Advances in knowledge: To the best of our knowledge, this is the first article to compare the influence of 4 cm vs 8 cm coverage size on cerebral perfusion parameters such as CBF, CBV, MTT and TTP in subjects with chronic carotid artery stenosis.

INTRODUCTION

In CT perfusion (CTP), the infusion of iodinated contrast follows non-contrast CT, therefore enabling the assessment of tissue attenuation changes recorded in the brain over time. Then afterwards, colour-coded maps are generated, and the quantification of perfusion parameters such as cerebral blood flow (CBF), cerebral blood volume (CBV), mean transit time (MTT) and time to peak (TTP) becomes possible. CTP in most cases remains the first choice in the management of patients with acute stroke and other cerebrovascular disorders. It is widely available and provides an easy and fast way of obtaining both morphological and perfusion-related parameters.¹

CTP parameters are acquired in a single rotation. Therefore, 64- or 128-slice coverage in a single rotation allows for a coverage size of 3–8 cm. There is an ongoing discussion whether the coverage size matters in terms of diagnosis of occlusions of the internal carotid artery (ICA) and middle cerebral artery. The opinion prevails that a coverage size of at least 7.5 cm would be optimal and an extended coverage size beyond 7.5 cm will not substantially affect any treatment decisions.^{2,3} Emmer et al⁴ compared infarct core volume on whole-brain CTP with several limited coverage sizes: 3, 4, 6 and 8 cm. They concluded that an 8 cm coverage might be a useful alternative if whole-brain perfusion is not available. However, with 6 cm

coverage or below, a substantial number of patients were misclassified with regard to infarct core volume. It is therefore inadvisable to make clinical decisions with regard to stroke infarct treatment choices based only on calculated infarct core volume on CTP studies when whole-brain CTP or optimized 8 cm coverage studies are not available.⁵ The 8 cm range in measurements of CTP parameters seems to be a better choice in clinical practice. However, this change in range can modify the absolute values of brain perfusion parameters withdrawn from CTP.

To the best of our knowledge, the impact of coverage size on global CBF, CBV, MTT and TTP parameters has not been investigated in patients qualifying for carotid stenosis stenting. Although prevention improved over the past decades, stroke and cerebrovascular disease remain the second leading cause of mortality in the world. Carotid screening is not routinely performed and the patient can present late, particularly in rural areas or developing countries. Patients with low CBF and CBV values have previously been described in the literature, but usually did not exceed 20–30% of the total investigated population.^{6–9} In populations with evident clinical symptoms in the course of chronic carotid stenosis, the perfusion impairment resulting in low CBV and CBF should be much more frequent.

The aim of this study was to compare whether the 4 cm and 8 cm coverage size have an influence on CBF, CBV, MTT and TTP in patients with low CBF and low CBV. We hypothesized that the coverage size would have an impact on CBF, CBV, MTT and TTP, similar to previously reported data with regard to the infarct volume.

METHODS AND MATERIALS

Patient population

During 2010–2014, 63 patients [29 (46%) females and 34 (54%) males; mean age of 69.44 years] (Table 1) qualified for carotid stenosis stenting procedure in the Department of Cardiac and Vascular Surgery of the Medical University of Gdansk. The experimental protocol and the study were approved by the relevant ethics committee of the Medical University of Gdansk. All volunteers gave written informed consent to participate in the study.

Patients with stenosis of >70% within a single ICA with concomitant neurological symptoms (dizziness, tinnitus, visual disturbances, headaches) were included in the study. In all patients, the duration of carotid artery stenosis was longer than 5 years (as proved by Doppler ultrasound). A general examination was performed before the experiment; subjects with an abnormal blood pressure or heart rate values were excluded from the study.

Stenosis was diagnosed on the basis of a Doppler examination according to the North American Symptomatic Carotid Endarterectomy Trial criteria.

Patients with bilateral haemodynamically significant (*i.e.* >70%) stenosis of the cranial arteries, complete occlusion of one vessel or patients who had experienced extensive ischaemic brain stroke were excluded from the study. Consequently, in all patients in the studied population, stenosis on the contralateral side was haemodynamically not significant (<50%). Patients with uncontrolled hyperthyroidism, renal insufficiency and hypersensitivity to iodine or history of adverse effects following the administration of contrast agents were also excluded from the study.

Imaging protocol

All perfusion CT scans were acquired using a 64-channel multidetector computed tomography (MDct) Light Speed VCT XT scanner (GE Healthcare Technologies, Milwaukee, WI) with 40 ml of the iodine-based intravascular contrast agent Optiray™ 350 (Mallinckrodt, St. Louis, MO) administered at the injection rate of 4 ml s⁻¹. After contrast injection, an additional bolus of 40 ml of physiological saline was administered.

Each study began with a cerebral tomography scan acquired without contrast administration to exclude potential bleeding, acute ischaemic stroke or features of increased intracranial pressure. The next stage involved the perfusion CT scan over a range of 4 or 8 cm of the brain.

CT scanning at 80 mm in volume shuttle mode (CTP 8 cm) was initiated 5 s after the start of the injection with the following acquisition parameters: tube voltage 80 kV, 500 mAs, slice

Table 1. Subject age, sex and radiation dose

	4 cm coverage size		8 cm coverage size		<i>t/z</i>	<i>p</i> -value
Age	Mean	70.36	Mean	67.62	-1.345	0.184
	SD	7.37	SD	8.10		
	<i>n</i>	42 ^a	<i>n</i>	21		
Sex	Male	24 (57.1%)	Male	10 (47.6%)	0.676	0.499
DLP	Mean	2838.30	Mean	2860.91	-0.168	0.866
	Median	2885.42	Median	2877.89		
	SD	73.65	SD	77.98		

DLP, dose-length product; *n*, number; SD, standard deviation.

^a21 randomized new cases and 21 cases from previous study.¹⁰

t/z, values of parametric Welch's *t*-test (letter *t*) or standardized nonparametric U Mann-Whitney's test (letter *z*) according to normality condition.

Figure 1. CT perfusion images: regions of interest (ROIs) were drawn in the reference CT image (a) and vessel-removed cerebral blood flow map (b). The left internal carotid artery (LICA) is narrowed.

thickness 5 mm, rotation time 0.4 s, field of view 25 cm, temporal sampling 3 s, total exposure time 13.6 s, interval 40 mm, gantry angle 0, image matrix 512×512 , 16 slices. A total of 336 slices from 21 patients (10 males) were obtained with a scan time of 46.6 s. The arterial input function was chosen within the anterior cerebral artery (Segment A2) on the level of the basal ganglia. The venous output region was selected from the superior sagittal sinus.

CT scanning at 40 mm in cine mode (CTP 4 cm) was initiated 5 s after the start of the injection with the following acquisition

parameters: tube voltage 80 kV, 150 mAs, slice thickness 5 mm, rotation time 1 s, field of view 25 cm, time interval between reconstructed images 0.5–1 s, total exposure time 45 s, interval 0 mm, gantry angle parallel to and above the orbital roof to avoid radiation exposure to the lens, image matrix 512×512 , eight slices. A total of 336 slices from 42 patients (24 males) were obtained with a scan time of 45 s. The arterial input function was chosen within the anterior cerebral artery (Segment A2) on the level of the basal ganglia. The venous output region was selected from the superior sagittal sinus.

Table 2. Concomitant diseases in 4 cm and 8 cm coverage size groups

	4 cm coverage size	8 cm coverage size	<i>z/a</i>	<i>p</i> -value
Smokers	15	6	0.564	0.573
	35.7%	28.6%		
Hypertension	36	18	<i>a</i>	1.000
	85.7%	85.7%		
Diabetes mellitus Type 2	12	5	0.405	0.686
	28.6%	23.8%		
Transient ischemic attack	11	4	<i>a</i>	0.755
	26.2%	19.0%		
Stroke	6	3	<i>a</i>	1.000
	14.3%	14.3%		
Coronary artery disease	24	13	−0.365	0.715
	57.1%	61.9%		
Lipid disorders	11	5	0.206	0.837
	26.2%	23.8%		
Myocardial infarction	15	7	0.188	0.851
	35.7%	33.3%		

^aFisher's exact test.

z/a, values of two-proportion *z*-test (letter **z**) or Fisher's exact test (letter **a**) according to frequency condition.

All of the listed acquisition parameters were applied as provided by the manufacturer for the brain perfusion study.

Image post-processing

A dedicated CTP 4 application (Brain Stroke Protocol; GE Healthcare Technologies, Milwaukee, WI) was used to analyze perfusion parameters at each of the brain levels within the scope of the study.

The following perfusion parameters, each of them capable of characterizing the changes in cerebral blood supply, were taken into consideration:

- (1) CBF was expressed in millilitre per 100 g wet weight of brain tissue per minute. This parameter provides information on the quantity of blood flowing across a particular region of the brain. The value of the parameter drops by 0.45% per year of life.¹¹
- (2) CBV calculated in millilitre per 100 g wet weight of brain tissue. This provides information on the amount of blood remaining in the microcirculation.
- (3) MTT reflects the time difference between the arterial inflow and the venous outflow. It is expressed in seconds.
- (4) TTP reflects the time elapsing until the maximum concentration of contrast agent is reached within the region of interest (ROI).

The data from the perfusion scan showing the first pass of the contrast agent were processed using the AW 4 diagnostic workstation (GE Healthcare Technologies, Milwaukee, WI).

They were used to plot the contrast concentration curves within the veins and arteries as well as to prepare colour maps of cerebral perfusion layers within the ROI.

Two experienced neuroradiologists independently drew two standardized elliptical mirrored ROIs manually determined at each analyzed level (Figure 1a,b), over the cortical grey matter to avoid fluid-filled spaces and post-infarct areas. The large vessels were automatically excluded *via* brain perfusion software.

Statistical analysis

In order to compare results of perfusion methods, differences in absolute CT values (MTT, CBV, CBF and MTT) and relative values (rMTT, rCBV, rCBF, rTTP—obtained as ratio of appropriate values from ipsilateral side to contralateral side to stenosis) were analyzed.

The general idea was to use data of all individual slices rather than averaged, per patient CT values. Although the mean values were the same in both approaches, the use of all slices seems to be more appropriate for two main reasons: sample sizes are greater and standard deviations are more correct for the whole brain. Eventually, both comparisons were discussed.

Normality was verified using the Shapiro–Wilk test. Differences between mean values in small groups were examined by Welch's *t*-test or Mann–Whitney *U*-test if necessary. Differences in fractions were checked using a two-proportion *z*-test or Fisher's exact test.

Table 3. Interrater variability

CT	Coverage size (cm)	Side	Bias	SD	Lower agreement limit	Upper agreement limit	rSDD (%)
MTT	8	Ipsilateral	0.118	0.424	−0.713	0.949	10.95
MTT	8	Contralateral	0.060	0.453	−0.828	0.949	11.40
MTT	4	Ipsilateral	0.022	0.253	−0.473	0.518	6.03
MTT	4	Contralateral	0.057	0.194	−0.324	0.437	4.82
CBV	8	Ipsilateral	0.036	0.216	−0.386	0.459	14.91
CBV	8	Contralateral	0.045	0.223	−0.393	0.482	13.80
CBV	4	Ipsilateral	0.005	0.133	−0.257	0.267	7.85
CBV	4	Contralateral	−0.002	0.126	−0.249	0.246	7.46
CBF	8	Ipsilateral	0.622	1.391	−2.105	3.349	4.84
CBF	8	Contralateral	0.944	2.107	−3.189	5.075	7.07
CBF	4	Ipsilateral	−0.264	1.240	−2.695	2.167	4.04
CBF	4	Contralateral	0.513	0.980	−1.408	2.434	2.61
TTP	8	Ipsilateral	−0.155	1.170	−2.449	2.139	4.60
TTP	8	Contralateral	−0.626	1.257	−3.091	1.838	4.99
TTP	4	Ipsilateral	0.407	0.745	−1.053	1.867	2.91
TTP	4	Contralateral	0.212	0.325	−0.425	0.849	1.31

CBF, cerebral blood flow; CBV, cerebral blood volume; MTT, mean transit time; rSDD, standard deviation of the relative differences; SD, standard deviation; TTP, time to peak.

Data from large groups did not need to satisfy the normality assumption for the use of the parametric *t*-test, according to the Central Limit Theorem. Hence, differences in absolute and relative values between the perfusion methods were assessed using only the parametric *t*-test. In addition, the comparison of absolute CTP values between methods was presented by box and whisker plots.

The level of significance was set at $\alpha = 0.05$. All calculated *p*-values were for two-tailed tests. All of the raw data were analyzed using the statistical software Statistica v. 10 (StatSoft, Tulsa, OK).

RESULTS

There were no statistically significant differences between fractions of males (females) in the 4 cm and 8 cm coverage size groups ($p = 0.370$). The groups were also homogeneous in terms of age, sex (Table 1) and concomitant diseases (Table 2). Radiation exposure expressed in dose-length product was similar in both groups (Table 1). The analysis was performed on individual slices and on a per-patient level.

Interrater variability

Interrater variability for absolute values separated for both hemispheres is shown in Table 3. The interrater variability (Table 3) presents the bias (mean of differences), lower and upper agreement limits designated according to the principle of Bland and Altman¹² and the standard deviation of the relative differences calculated as the difference for each pair of observations divided by their mean. Because no systematic difference was

found, for further analysis, data from each hemisphere were pooled together. Data finally used for analysis were the mean of CT values received from two independent raters.

Analysis based on individual slices

The CBF and CBV values were higher in the 4 cm coverage size than in the 8 cm coverage size (by 14.7 and 10.7% on the ipsilateral side and 17.2 and 7.8% on the contralateral side, respectively; all $p < 0.001$). The MTT value was higher in the 4 cm coverage size than in the 8 cm coverage size on the ipsilateral side (9.6%; $p < 0.001$). There was no difference between MTT values in the contralateral size. There were no differences between TTP values on the ipsilateral and contralateral sides (Table 4, Figure 2a–d).

The use of relative indices revealed differences between the ratios of rMTT and rTTP, both were higher in the 4 cm coverage size than in the 8 cm coverage size (8.2%, $p < 0.001$, and 1.1%, $p < 0.005$) (Table 5).

Analysis performed on per-patient basis

The difference between 4 cm coverage size and 8 cm coverage size remained statistically significant for CBF (14.7%, $p < 0.05$, on the ipsilateral side and 17.2%, $p < 0.005$, on the contralateral side) and for CBV on the ipsilateral side (10.7%; $p < 0.05$) (Tables 6 and 7).

DISCUSSION

There were two main findings in this study: (1) absolute CBF and CBV values and relative rMTT and rTTP indices in patients

Table 4. Absolute CT perfusion parameter values (all slices)

Brain hemisphere	Perfusion parameter	$n_1 = n_2 = 336$	8 cm coverage size	4 cm coverage size	<i>t</i> -test	<i>p</i> -value
Ipsilateral side	MTT	Mean	4.340	4.702	−3.546	<0.001
		SD	1.183	1.454		
Contralateral side	MTT	Mean	4.319	4.420	−1.040	0.299
		SD	1.271	1.239		
Ipsilateral side	CBV	Mean	1.642	1.799	−4.876	<0.001
		SD	0.437	0.396		
Contralateral side	CBV	Mean	1.693	1.800	−3.239	0.001
		SD	0.461	0.391		
Ipsilateral side	CBF	Mean	33.866	38.369	−4.989	<0.001
		SD	11.435	11.959		
Contralateral side	CBF	Mean	34.443	40.073	−6.721	<0.001
		SD	11.114	10.593		
Ipsilateral side	TTP	Mean	25.985	26.357	−1.422	0.155
		SD	3.170	3.601		
Contralateral side	TTP	Mean	25.857	26.093	−0.869	0.385
		SD	3.351	3.678		

CBF, cerebral blood flow; CBV, cerebral blood volume; MTT, mean transit time; *n*, number; SD, standard deviation; TTP, time to peak.

Figure 2. (a-d) Box-and-whisker plots of absolute CT perfusion parameters (all slices): (a) box-and-whisker plot of mean transit time; (b) box-and-whisker plot of cerebral blood volume; (c) box-and-whisker plot of cerebral blood flow; (d) box-and-whisker plot of time to peak. Conf. Interval, confidence interval; SE, standard error.

with low CBF and low CBV are highly dependent on coverage size and (2) we recommend using the same coverage size to assess global cerebral perfusion parameters in studied groups of patient, especially when evaluating the results of treatment.

To the best of our knowledge, this is the first article to compare the influence of 4 cm vs 8 cm coverage size on cerebral perfusion parameters such as CBF, CBV, MTT and TTP in subjects with chronic carotid artery stenosis. First, we would like to highlight a few methodological issues. Radiation exposure is unavoidable in CTP and represents one of the main disadvantages of this imaging technique. For this reason, subsequent comparison of 4 cm vs 8 cm coverage in the same subjects is impossible owing to ethical reasons. In our study, we selected two groups of subjects that were well matched in terms of age, sex and concomitant diseases. The data were collected within a relatively short period of time, from 2010 to 2014. All subjects had had a stenosis diagnosed on the basis of a Doppler examination more

than 5 years before the first neurologic symptoms. Owing to strict inclusion criteria consisting of stenosis of $>70\%$ within a single ICA with concomitant neurological symptoms (dizziness, tinnitus, visual disturbances and headaches), our population was very homogeneous in terms of cerebral haemodynamic parameters and was characterized by low CBF and low CBV.¹³ Although the relatively narrow population can be seen as a limitation of this study, population homogeneity increased the reliability of our results. Patients with bilateral haemodynamically significant (*i.e.* $>70\%$) stenosis of cranial arteries were excluded from the study. As a result, in all patients in the studied population, stenosis on the contralateral side was haemodynamically not significant ($<50\%$).^{14–18}

Global perfusion parameters may be influenced by heart rate. For this reason, subjects with an abnormal heart rate and blood pressure were excluded from the study. As long as heart rate is within the normal ranges, there are no direct interactions

Table 5. Relative CT values (all slices)

CT	$n_1 = n_2 = 336$	8 cm coverage size	4 cm coverage size	<i>t</i> -test	<i>p</i> -value
rMTT	Mean	1.034	1.103	−3.136	0.002
	SD	0.219	0.335		
rCBV	Mean	0.989	1.008	−1.429	0.154
	SD	0.199	0.137		
rCBF	Mean	1.010	0.973	1.871	0.062
	SD	0.262	0.258		
rTTP	Mean	1.007	1.012	−1.185	0.236
	SD	0.054	0.052		

n, number; SD, standard deviation.

between heart rate and the parameters CBF, CBV, MTT or TTP.¹³ Finally, as the choice of reference artery and venous regions are critical in CTP,¹⁹ the arterial input function within the anterior cerebral artery (Segment A2) on the level of the basal ganglia and the venous output region from the superior sagittal sinus were selected in both groups. ROIs were determined at each analyzed level by the two experienced neuro-radiologists; large blood vessels, fluid-filled spaces and post-infarct areas were avoided.

Our results indicate that coverage size matters when CTP is used to assess global perfusion parameters. The 4 cm coverage yielded higher CBF, CBV, rMTT and rTTP values than the 8 cm

coverage size. The difference in CTP values can be attributed to the differences in protocols in 4 cm-thick scans vs 8 cm-thick scans. The tube current and gantry rotation times are different in those protocols and to achieve an 8 cm coverage, the images are acquired with a temporal resolution of 3 s owing to toggling the table back and forth instead of 1 s in regular scans with 4 cm coverage. The 4 cm cine scan has a shorter temporal window and acquires more samples than the 8 cm volume shuttle mode. Volume shuttle has a temporal sampling window of approximately 2.2 s, while the cine acquisition mode is continuous exposure.

The rotation time difference for the perfusion 4 cm and 8 cm are totally different; 1 s for cine mode—CTP 4 cm and 0.4 s for

Table 6. Absolute CT perfusion parameters values (mean per patient)

Brain hemisphere	Perfusion parameter	$n_1 = 21$ $n_2 = 42$	8 cm coverage size	4 cm coverage size	<i>t/z</i>	<i>p</i> -value
Ipsilateral side	MTT	Mean	4.340	4.702	−0.620	0.535
		SD	0.859	1.347		
Contralateral side	MTT	Mean	4.319	4.435	−0.327	0.744
		SD	0.979	1.122		
Ipsilateral side	CBV	Mean	1.642	1.799	−2.267	0.023
		SD	0.271	0.315		
Contralateral side	CBV	Mean	1.693	1.800	−1.451	0.147
		SD	0.300	0.314		
Ipsilateral side	CBF	Mean	33.866	38.369	−2.136	0.038
		SD	7.023	9.378		
Contralateral side	CBF	Mean	34.443	40.073	−3.053	0.004
		SD	6.674	7.326		
Ipsilateral side	TTP	Mean	25.985	26.357	−0.518	0.605
		SD	3.102	3.589		
Contralateral side	TTP	Mean	25.857	26.093	−0.260	0.796
		SD	3.257	3.654		

CBF, cerebral blood flow; CBV, cerebral blood volume; MTT, mean transit time; *n*, number; SD, standard deviation; TTP, time to peak.

t/z, values of parametric Welch's *t*-test (letter *t*) or standardized nonparametric U Mann-Whitney's test (letter *z*) according to normality condition.

Table 7. Relative CT values (mean per patient)

CT	$n_1 = 21$ $n_2 = 42$	8 cm coverage size	4 cm coverage size	t/z	p-value
rMTT	Mean	1.034	1.097	-0.104	0.917
	SD	0.153	0.313		
rCBV	Mean	0.989	1.008	-0.999	0.318
	SD	0.070	0.072		
rCBF	Mean	1.010	0.973	0.994	0.324
	SD	0.086	0.212		
rTTP	Mean	1.007	1.012	-0.416	0.678
	SD	0.027	0.035		

n, number; SD, standard deviation.

t/z, values of parametric Welch's t-test (letter **t**) or standardized nonparametric U Mann-Whitney's test (letter **z**) according to normality condition.

volume shuttle—CTP 8 cm. The rotation time for volume shuttle is faster so that the temporal window is not too wide. Different scores between perfusion parameters may vary owing to the variation in the temporal sampling that occurs between scanning at 4 cm in cine mode vs 8 cm volume shuttle mode. The temporal sampling is increased when scanning 8 cm owing to the shuttle technique. This needs to be compensated for in the CTP 4 software advanced settings when the 8 cm data are processed.

Quantitative CTP data may vary considerably depending on the post-processing software. Actually, software differences constitute the primary cause of variability in perfusion results relative to interoperator and intraoperator differences.^{20–22} The strength of our study is that we used equipment from the same manufacturer and used the same post-processing procedure for all subjects. Furthermore, both experienced neuroradiologists independently drew two standardized elliptical mirrored ROIs (an area of approximately 5 cm each) on the section level of the reference CT image (Figure 1a) over the cortical grey matter of the middle cerebral artery territory.

Taken together, the 4 cm coverage size seems to be better suited for detecting perfusion parameters than the 8 cm coverage size owing to the higher density of scans. Furthermore,

post-processing is quicker and more effective in the 4 cm than in the 8 cm coverage size. Clearly, when assessing the effectiveness of carotid surgery procedures, the data obtained from only the same coverage size can be compared.

Cerebral perfusion can be measured by various tools other than CTP, including positron emission tomography (PET),^{23,24} MRI,²⁵ single-photon emission CT²⁶ and xenon CT.²⁷ Of these techniques, PET is the current standard of reference for assessing CBF and brain metabolism. However, all of the above-mentioned techniques are more expensive and less available in everyday clinical practice than CTP, particularly in rural areas or developing countries. CTP has been shown to correlate well with the PET data.^{24,25} CTP has been extensively used in recent years to evaluate chronic ischaemia associated with haemodynamic compromise resulting from high-grade carotid stenosis.^{28,29} Cover size needs to be taken into account in such studies.

To conclude, we have shown that absolute CBF and CBV values and relative rMTT and rTTP indices in patients with low CBF and low CBV are highly dependent on coverage size. When CTP is used to assess the effectiveness of surgical procedures on the stenotic carotid artery, data obtained using only the same coverage size are comparable.

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