CAPABILITIES OF INFRARED THERMOMETRY AND THERMOGRAPHY IN ACUTE AND CHRONIC CEREBRAL CIRCULATION DISTURBANCES

J.P. Potekhina** Prof., **A.V. Gustov** Prof., **I.A. Gafiatullin, M.V. Golovanova

Nizhny Novgorod State Medical Academy, Russia
LLC CEM-ThermoDiagnostics, Nizhny Novgorod, Russia

INTRODUCTION

Currently, one of the main problems of public health is cerebrovascular pathology – the third cause of death and one of the reasons of disability of people in many countries. According to WHO experts, in the future the number of cerebrovascular diseases will be merely increasing due to ageing of population and the increase of such risk factors as arterial hypertension, diabetes mellitus, hypercholesteremia, smoking, obesity, hypodynamia, etc [1].

Chronic cerebral circulation disturbances number the major part (96%) in the structure of cerebrovascular diseases. The frequency of chronic cerebral ischemia grows with the increase of years. Cognitive disorders of vascular genesis are revealed in 5–22% of elderly. In autopsy various vascular diseases are found in a third of elderly people [2]. At the same time, almost half of all the cases of chronic cerebral ischemia that can lead to stroke is recorded in working population. [1]. At early stages, chronic cerebral ischemia can be asymptomatic or with minimum clinical presentation, so patients do not turn to doctors for duly help and do not receive the treatment required. For the same reason strokes often occur against the background of "visible health". Stroke incidence rate is increasing in people of working age; and stroke is a leading cause of disability of population. Taking into account medical, social and economical aspects of the spread of cerebrovascular pathology, WHO experts have declared a stroke to be a global epidemic threatening national safety. As a whole, all these factors necessitate to prepare a package of preventive measures, modern diagnosis of cerebrovascular diseases holding a ranking place [3, 4].

Patients who survived a stroke or a transient ischemic attack are frequently nervous about the possibility of attack repeat and enquire what they are to do. In 10% of patients with transient ischemic attacks hospitalized by emergency, a stroke develops within 90 days even if traditional therapy is administered [5]. Reanalysis of findings of Oxfordshire Community Stroke Project has showed the risk of stroke to achieve 12% in the first 90 days [6]. To reach a maximum effect, the treatment is to be started as soon as possible, as well as the monitoring of patient's condition in the course of treatment.

According to diagnostic value, neuroimaging techniques – computer tomography or magnetic resonance imaging – head the list in cerebrovascular pathology diagnosis, as they enable to reveal cerebral organic changes of vascular genesis [7; 8]. However these methods do not give adequate information concerning the state of cerebral circulation, therefore they have limitations in monitoring patients' condition and in the control of treatment effectiveness. Therefore, there are needed methods of control of the level of cerebral blood supply, easy and available to people that could estimate the effectiveness of preventive and therapeutic intervention in chronic and acute cerebral circulation disturbances.

Circulation failure is one of the causes of skin temperature changes. Disturbed arterial circulation in internal carotid artery that supplies the brain is known to be manifested in the reduction of skin temperature of the orbital interior angle and medial superciliary area [9].

The aim of the work was to study the capabilities of infrared thermometry and thermography in cerebrovascular pathology.

METHODS AND MATERIALS

There have been examined the patients with acute and chronic disturbances of cerebral circulation:

- 61 patients with chronic cerebral ischemia, among them 22 men aged 51–79 yrs (median age: 59 years old) and 39 women aged 46–85 yrs (median age: 60 years old), and 40 of them have been treated in in-patient department within 3 weeks;
- 60 patients with ischemic stroke, aged 24–73 yrs (median age: 53 years old) in peracute and early rehabilitation period, and 33 men and 27 women of them have been treated in a specialized hospital within 3 week followed by rehabilitation period in specialized country in-patient department for 24 days.

The control group consisted of apparently healthy 60 people – 32 men aged 17–68 yrs (median age: 27 years old) and 28 women aged 17–62 yrs (median age: 34 years old).

All the patients underwent a complex of the investigations required. Besides, infrared thermometry and thermography using personal thermograph CEM®-ThermoDiagnostics was used on admission to hospital and then every week to the end of treatment. The procedure was carried out in the morning before the meal, at room temperature, in the absence of air flow, away from heat. Within 10 minutes before the examination the patients were lying or sitting in a comfortable armchair.

Personal thermograph CEM®-ThermoDiagnostics is a hardware and software complex (Fig. 1). It includes infrared thermometer that measures the intensity of thermal radiation in any areas of the body and transfers information to the computer, and "CEM® Thermo Image Bio" program (State Registration Certificate No. 2011611309 dated 09.02.2011) that makes thermograms on the photos of the patient's areas of concern or on the 3D model of human body.

Fig. 1. *Personal Thermograph CEM®-ThermoDiagnostics*

The temperature was measured in the areas that reflex the blood flow level in internal and external carotid arteries, as well as in vertebrobasilar system:

- central frontal point – along the medial line of the forehead, 4.5–5.5 cm above the level of the inner angle of the eye;
- medial superciliary points – 3–3.5 cm above the inner angle of the eye;
- medial orbital points – immediately above the inner angle of the eye;
- temporal points – 5–6 cm above the external auditory canal;
- occipital points – immediately below greater occipital tubers.

Statistical processing was carried on using methods of nonparametric statistics, by means of the program Statistica 7.0. To find out the differences between the samplings, there were used Wilcoxon criterion for paired comparison and Mann-Whitney U-test. Critical level of significance in testing statistical hypotheses was taken equal to 0.05.

RESULTS AND DISCUSSION

The analysis of temperature measurements of healthy people heads showed that normally there is spread of absolute values of temperature of the head surface within the range 26.8–35.6° C, and temperature asymmetry in representative points on the head is no more than 0.6° C (Table 1).

Table 1. *Thermometric values in representative points on the head of apparently healthy people*

Name of the point	Temperature values, °C	Temperature asymmetry, °C
Central frontal point	29.4-35.2, median 33.6	
Medial orbital point	29.0-35.2, median 33.6	0-0.6, median 0.2
Medial superciliary point	29.6-35.0, median 33.6	0-0.6, median 0.2
Temporal point	27.2-35.6, median 33.6	0-0.6, median 0.2
Occipital point	26.8-35.2, median 32.7	0-0.6, median 0.2

In patients with chronic cerebral ischemia there is spread in absolute temperature values on the head within the range 26.0–35.6° C, and in all the representative points it is statistically significantly lower than in healthy people; temperature asymmetry on the head ranges from 0 to 4.2° C, and in all the representative points – statistically significantly higher than in healthy people (Table 2). Figure 2 shows a frontal thermogram of a patient with chronic cerebral ischemia.

The results of treatment in all the patients were estimated as good. The analysis of dynamics in the course of chronic cerebral ischemia treatment demonstrated that:

- there was temperature increase in all treated patients at least in one representative point;
- there was no temperature decrease in any patient within the treatment process;
- the dynamics of the temperature measured was irregular and asymmetric in various representative points;
- the increase of temperature at least in one representative point in the majority of patients started after 2 weeks' treatment in hospital;

– more frequently the temperature rose in medial superciliary and occipital points, therefore, just in these points the temperature is to be controlled first of all.

Table 2. *Thermometric values in representative points on the head of patients with chronic cerebral ischemia*

Name of the point	Temperature values, °C	Variations from healthy	Temperature asymmetry, °C	Variations from healthy
Central frontal point	31.0-34.2, median 32.9	p=0.005		
Medial orbital point	30.4-34.6, median 33.2	p=0.01	0-1.8, median 0.2	p=0.04
Medial superciliary point	30.2-34.4, median 32.7	p=0.001	0-0.8, median 0.4	p<0.001
Temporal point	26.0-35.6, median 30.1	p<0.001	0-3.8, median 1.0	p<0.001
Occipital point	26.2-35.6, median 30.4	p<0.001	0-4.2, median 0.8	p<0.001

Fig. 2. *Frontal thermogram of the patient with chronic cerebral ischemia superimposed on 3D cranial model.*

Temperature values of skin integument of the head in ischemic stroke differ slightly in various periods of the disease. The temperature rises significantly statistically in early rehabilitation period in the occipital point and in the area of medial orbital edge (Table 3), that can be indicative of the establishment of flow in internal carotid artery and vertebrobasilar system. Temperature asymmetry in this case is not high on the average, though in some patients it reaches 2.4° C. In different periods of the disease the temperature asymmetry does not change significantly statistically.

The results of treatment in all the patients were estimated as good. The temperature of the head skin in representative points in 50% of cases began to increase even in two weeks after the treatment had started, though statistically significant changes in ischemic stroke occurred only after three weeks of treatment in hospital. In aggravation there was the increase of temperature asymmetry in various points that can be regarded as unfavourable prognostic sign.

The analysis of dynamics in acute period of cerebral ischemia demonstrated that:

– there was temperature increase in all treated patients after three weeks of treatment initiation at least in four representative points on the head;
– there was no temperature decrease in any patient within the treatment process;
– the dynamics of the temperature measured was irregular and asymmetric in various representative points;
– more frequently the temperature rose in medial orbital, medial superciliary and temporal points, therefore, just in these points the temperature is to be controlled first of all.

In early rehabilitation period of treatment there was improvement in all the treated patients. The temperature of head skin practically did not change, and the goodness of fit of the treatment administered was the stability of values.

Table 3. *Thermometric values in representative points on the head in stroke*

	Peracute period		Early rehabilitation period		Temperature differences
Name of location	Temperature values, °C	Temperature asymmetry, °C	Temperature values, °C	Temperature asymmetry, °C	
Central frontal point	32.4-34.2, median 33.6		30.8-35.0, median 33.5		p>0.05
Medial orbital	32.0-35.0, median 33.6	0.2-1.0, median 0.4	31.6-35.8, median 34.4	0.2-2.0, median 0.4	p=0.04
Medial superciliary	31.8-34.4, median 33.4	0.2-2.4, median 0.4	30.8-35.4, median 33.8	0.2-2.0, median 0.4	p>0.05
Temporal point	31.8-35.6, median 34.4	0.2-2.2, median 0.8	31.2-35.6, median 34.4	0.2-1.6, median 0.4	p>0.05
Occipital point	29.6-35.8, median 34.0	0.2-2.0, median 0.4	31.6-35.8, median 34.6	0.2-1.4, median 0.2	p=0.02

CONCLUSION

Thus, for the first time there have been obtained temperature absolute values of head skin integument measured in infrared range in healthy people and in patients with cerebral circulation disturbances. The findings let us establish the scheme of early preclinical diagnosis of chronic cerebral ischemia and the risk of stroke, as well as recommend to use personal thermograph CEM®-ThermoDiagnostics to monitor the condition of patients with cerebrovascular pathology and assess the treatment effectiveness.

"CEM® Thermo Image BIO" program is rather simple, so it can be used by both doctors and at home – by those who care for their health and by patients or their relatives. Regular examinations are of primary importance in those who have risk factors: age (after 40), smoking, hypodynamia, the presence of arterial hypertension, diabetes mellitus and obesity.

Personal thermograph CEM®-ThermoDiagnostics has all the advantages of thermovision cameras: absolute safety both for patients and medical staff, noninvasive character, unlimited retest frequency, results reproducibility, ease of use. Moreover, CEM®-ThermoDiagnostics has the following additional advantages: availability, portability, the possibility to measure temperature with optimal accuracy in any areas of the body including hair-covered. Personal thermograph CEM®-ThermoDiagnostics does not need any specially equipped room.

REFERENCES

1. **Mitschenko T.S., Shestopalova L.F.** Dyscirculatory encephalopathy: modern views on pathogenesis and diagnosis // Health of Ukraine. – 2006. – No 15–16. In Russian.
2. **Grigsby J, Kaye K, Shertterly SM et al.** Prevalence of disorders of executive cognitive functioning among elderly // Neuroepidemilogy. – 2002; 21.
3. **Varakin Yu.Ya.** Epidemiological aspects of prevention of cerebral circulation disorders// Nerve diseases. – 2005; 2: 4–10. In Russian.
4. Stroke. Principles of diagnostics, treatment and prevention// N.V. Veretschagina, M.A. Piradova, Z.A. Suslina – Moscow: Intermedika, 2002. – 208 p. In Russian.
5. **Johnston S.C., Gress D.R., Browner W.S., Sidney S.** Short-term prognosis after emergency department diagnosis of TIA // JAMA 2000; 284: 2901–906.
6. **Warlow C., Sudlow C., Dennis M., Wardlaw J., Sandercock P.** Stroke // Lancet. – 2003; 362: 1211–1224.
7. **Korf E., Wahlund L., Visser P. et al.** Medial temporal lobe atrophy on MRI predicts dementia in patients with cognitive impairment. Neurology 2004; 63: 94–100.
8. **Munoz D.** Leukoaraiosis and Ischemia: Beyond the Myth. Stroke 2006; 37; 1348–1349.
9. **Wood E.H.** Thermography in the diagnosis of cerebrovascular disease, Radiology, 1965, V.85, № 2, p. 270–283.