

The state of cerebral and central hemodynamics in patients with neuroischemic form of diabetic foot syndrome is associated with chronic heart failure

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ABSTRACT

The aim of the study was to study the results of ultrasound dopplerography of the vessels of the head and heart in patients with the neuroischemic form of diabetic foot syndrome associated with chronic heart failure in ischemic heart disease.

Material and methods of research. During 2021, on the basis of the Department of Surgery of AndGovMI and RSNPMCE of the Ministry of Health of the Republic of Uzbekistan, the estate of Academician E.H. Turakulov, 64 patients with SDS neuroischemic form were examined. The patients were divided into 4 groups:

1 group – patients with type 2 diabetes and neuroischemic form of SDS and CHD – 15 patients,
Group 2 – patients with type 2 diabetes and neuroischemic form of SDS without CHD – 18 patients,

group 3 – patients with type 2 diabetes and neuroischemic form of SDS, CHD and dyscirculatory encephalopathy 2-3 ct – 16 patients.

Group 4 – persons with coronary heart disease without disorders of carbohydrate metabolism – 15 patients.

Healthy volunteers (n=20) formed a control group.

All patients were subjected to general clinical, biochemical hormonal and instrumental methods of examination - ultrasound Dopplerography of the vessels of the brain, lower extremities, ECG, Echo ECG, bacteriological analysis of the discharge from the wound, as well as statistical methods.

The results of the study. In the main 3 groups of patients with type 2 diabetes, during metabolic stimulation of the endothelium of SMA, a negative response was obtained in 38 out of 45 patients (84.4%) of the patient, in 7 (15.5%) patients – a paradoxical SMA response. In group 4 (comparison group), when assessing cerebrovascular reactivity, reliable dynamics of the peak systolic blood flow rate of SMA up to 14%, the time-averaged maximum blood flow rate up to 28% ($p < 0.05$) was obtained. Only 6 (40%) patients had a negative SMA reaction.

There is a significant difference in the indicators of central hemodynamics in the studied groups compared with the norm: for example, LV CDR, CSR, CDR, LV CSR ($p < 0.05$), data on the average pressure in the pulmonary artery, the time of slowing down the blood flow of early diastolic filling, TSSLJ ($p < 0.001$), PV, the ratio of peak wave velocities E and A, the time of isovolumic relaxation of LV, MMLJ, IMLJ ($p < 0.05$).

Conclusions. 1. The combined effect of hemodynamic and metabolic disorders has the greatest damaging effect on the endothelium of the arteries. In all patients with type 2 diabetes mellitus in combination with coronary heart disease, dysfunction of the endothelial mechanism of vascular tone regulation was revealed - in 84%. 2. Among the risk factors, hereditary burden of diabetes prevailed - only 21 cases out of 60 (35%), smoking – only 49 cases (81.6%), alcoholism – 16 cases (26.6%). 3. Significant deviations of central hemodynamic parameters were revealed in the studied groups.

KEYWORDS: diabetic foot syndrome, dopplerography

INTRODUCRION

Diabetes mellitus (DM) is a chronic metabolic disease with hyperglycemia resulting from deficiency or resistance of the hormone insulin secreted by the pancreas. [1 , 2] Against the background of neuropathy and ischemia associated with peripheral vascular damage, a diabetic foot formed when an infection is attached may be in 15% of DM patients. Diabetic foot is a serious complication of DM, requiring amputation in approximately 7-20% of patients. [3] Peripheral artery disease is the most important factor determining the outcome of diabetic foot, classified as neuropathic, ischemic and neuroischemic. [4]

Diabetic foot is a macrovascular complication of diabetes mellitus (DM). It has been found that patients with diabetic foot have a higher frequency of cardiovascular risk factors, such as smoking, hypertension and coronary heart disease. ($P < 0.05$ for each). Similarly, glucose, glycated hemoglobin, neutrophils, urea, creatinine, potassium, uric acid, alanine aminotransferase, aspartate aminotransferase, C-reactive protein and brain natriuretic protein were higher in patients with diabetic foot; the level of high-density lipoprotein cholesterol was significantly lower. LV wall thickness and diameter were higher, and LV LV was lower in patients with diabetic foot ($P < 0.05$ for each). LV systolic function was significantly impaired in patients with diabetic foot. This may be due to the increased frequency of cardiovascular risk factors in these patients. However, a significant improvement in LV-GLS values after treatment of diabetic foot showed that diabetic foot itself is an important cause of LV systolic dysfunction. [5]

As far as we know, there are no studies on the effect of diabetic foot on LV function before treatment and on the effect of diabetic foot treatment on LV systolic function in patients with diabetic foot.

The authors identified groups of patients in the polyclinic of diabetic foot during dispensary observation, in some cases with a significant improvement in LV systolic function in the treatment of diabetic foot. However, since many patients do not have symptoms, the authors suggested that the value of the total longitudinal LV deformity (LV-GLS), which is a more sensitive and objective parameter, can be changed by the treatment of diabetic foot. [5]

Other authors report an association between diabetic foot and cardiovascular risk and consistent with the role of putative cardiovascular surrogate markers of arterial stiffness indices and endothelial function. [6]

Katakami N. et al. [7] recently showed that the assessment of baPWV (pulse wave velocity), in addition to carotid artery CMM and usual risk factors, improves the ability to identify diabetics at high risk of cardiovascular diseases, whereas more recently Gomez-Marcos et al. [8] analyzed the relationship between the cardio-ankle vascular index (CAVI), the new general stiffness index and target organ damage (POM), vascular structure and function, as well as cardiovascular risk factors in Caucasian patients with type 2 diabetes mellitus or metabolic syndrome, suggesting that CAVI is positively associated with BMI, cf-PWV, ba-PWV (pulse wave velocity), CAIx and PAIx (augmentation indices), regardless of cardiovascular risk and the medication used.

At the same time, there are practically no works in the literature devoted to the study of peripheral vascular hemodynamics in patients with SDS associated with CHF. In the literature, the relationship between diabetic foot and other macrovascular complication of DM has not been clarified.

All of the above highlights the urgency of this problem.

The aim of the study was to study the results of ultrasound dopplerography of the vessels of the head and heart in patients with the neuroischemic form of diabetic foot syndrome associated with chronic heart failure in ischemic heart disease.

MATERIALS AND METHODS

During 2021-2022, we examined 70 patients with neuroischemic SDS on the basis of the Department of Surgery of AndGovMI. The patients were divided into 4 groups:

1 gy – patients with type 2 diabetes and neuroischemic form of SDS and CHD – 21 patients ,
Group 2 – patients with type 2 diabetes and neuroischemic form of SDS without CHD – 18 patients,

group 3 – patients with type 2 diabetes and neuroischemic form of SDS, CHD and dyscirculatory encephalopathy 2-3 ct – 16 patients.

Group 4 – persons with coronary heart disease without disorders of carbohydrate metabolism – 15 patients.

Healthy volunteers (n=20) formed a control group.

All patients were subjected to general clinical, biochemical (glycemia, glycated hemoglobin, PTI, ALT, AST, bilirubin, urea, blood creatinine), hormonal (IRI, C-peptide, inflammatory marker-proinflammatory cytokine TNF-a, vascular endothelial growth factor (VEGF-A), platelet growth factor (PDGF) and instrumental methods of research - ultrasound dopplerography of the vessels of the brain, lower extremities, ECG, Echo-ECG, bacteriological analysis of the discharge from the wound, as well as statistical methods.

The obtained data were processed using Microsoft Excel and STATISTICA_6 computer programs. The differences between the groups were considered statistically significant at $P \leq 0.05$. The mean values (M) were calculated, the standard deviations of the mean (m)

The reliability of the differences in the level between the groups was estimated by the value of the confidence interval and the Student's criterion (p). The differences were considered statistically significant at $p < 0.05$.

RESULTS AND DISCUSSION

Table 1. shows the distribution of examined patients by gender and age.

Table.1.

Distribution of patients by gender and age (WHO, 2017)

Age , years	Number of men	Number of women
18-44 (young age)	-	-
45-59 (middle age)	12 (25%)	8(32,0%)
60-74 (old age)	24 (50,0%)	9 (17,9%)
75 and older (senile age)	10 (20,8%)	5(2,8%)
Total: n = 70	48 (68,5%)	22 (31,5%)

As can be seen from Table 1, patients in the age category from 45 to 74 years prevailed, both among men and women – 48/22 cases, respectively.

Table 2. shows the duration of observations by groups. As can be seen from Table 2., the predominant number of patients were observed for up to 1 year and up to 2 years – 35/19 (50%/29.7%) patients, and the smallest number – up to 3 years - 6 patients, respectively (9.3%).

Table 2.

Duration of observations by groups (abs. number and %)

Duration of observations, years	Groups of patients, abs.			
	1a gr N=`21	1b gr N= 18	1c gr N=16	2a gr N=15
Up to 1 year, n = 35	12 (57,1%)	8 (44.4%)	7 (43.8%)	8 (53.3%)
From 1 to 2 years, n = 19	4 (19,0%)	5 (27,7%)	5 (31,2%)	5 (33,3%)
2 years, n = 10	3 (14,3%)	3 (16,6%)	3 (18,8%)	1 (6,7%)
3 years, n = 6	2 (9,5%)	2 (11,1%)	1 (6,3%)	1 (6,7%)

Note: in the % column, the percentage of patients from the total number of patients in the group is given

Table 3 shows the initial clinical characteristics of the patients of the cohort under study – patients of the study groups.

Table 3

Clinical and anamnestic characteristics of patients included in the study

Attribute/indicator	1 gr N=` 21	2 gr N= 18	3 gr N=16	4 gr N=15
men / women	18/3^	16/2^	14/ 2^	11/4^
Hereditary burden of DM 2, n (%)	7 (33,3%)^	7 (38,8%)^	5 (41,6%)^	4 (41,6%)^

Smoking, n (%)	15 (71,4%)	15 (83,3%)	15 (93,7%)	11 (73,3%)
Alcoholism , n (%)	6 (29%) [^]	4 (22%) [^]	5 (312%) [^]	4 (27%) [^]
Number of foot surgeries, n (%)	21(100%) [^]	18 (100%) [^]	16 (100%) [^]	15 (100%) [^]
Limitation of SD 2, years	15,1±2,2***	17,1±2,4***	23,1±2,6 ***	-

Note : * – p<0.05 with groups 1 and 2., ** – p<0.05 with groups 2 and 3, *** p<0.05 with groups 1 and 3. ..[^] - p>0.05

As can be seen from Table 3, there were no special clinical and anamnestic differences in the groups. The risk factors were dominated by hereditary burden of diabetes - only 23 cases out of 70 (33%), smoking – only 56 cases (80%), alcoholism – 19 cases (27%).

Patients presented complaints of various kinds, presented in the table

Table 4

Frequency of complaints by group (abs, %)

Violations	1 gr N=` 21	2 gr N= 18	3 gr N=16	4 gr N=15
headaches	12 (57,1%)	4(22,2%)	15(93,7%)	5(33,3%)
dizziness	6 (28,5%)	4(22,2%)	14 (87,5%)	5(33,3%)
noise in the head	8(38,0%)	3(16,6%)	14(87,5%)	4(26,6%)
memory decline	7 (33,3%)	7(38,8%)	15(93,7%)	2(13,3%)
bad dream	12 (57,1%)	16(88,8%)	16(100%)	8(53,3%)
pain in the legs	21 (100%)	18 (100%)	16 (100%)	-
numbness of the legs	21(100%)	18 (100%)	16 (100%)	-
heart pain	21(100%)	18(100%)	16(100%)	12(80%)
shortness of breath at rest	21(100%)	18(100%)	16(100%)	13 (86,6%)
swelling of the feet	21(100%)	18(100%)	16(100%)	11 (73,3%)

Note : * – p<0.05 with groups 1 and 2., ** – p<0.05 with groups 2 and 3, *** p<0.05 with groups 1 and 3. ..[^] - p>0.05

As can be seen from Table 3, there were no special clinical and anamnestic differences in the groups. The risk factors were dominated by hereditary burden of diabetes - only 23 cases out of 70 (33%), smoking – only 56 cases (80%), alcoholism – 19 cases (27%).

Patients presented complaints of various types, presented in Table 4.

Table 4

Frequency of complaints by group (abs, %)

Indicators	1 gr N=` 21	2 gr N= 18	3 gr N=16	4 gr N=15
Thickness of KIM CFA (mm)	1,32±0,07*	1,28±0,03*	2,46±0,02 **	1,18±0,09
The presence of atherosclerotic plaques in the lower arteries	14/93,3%	11/61%	15/93.7%	7/46,6*

limbs (n/%)				
The thickness of the KIM CCA (mm)	1,24±0,06	1,20±0,05	2,42±0,07**	1,12±0,08
The presence of atherosclerotic plaques in the CCA (n/%)	9/60 %	6/33.3%	14/87.5:	6/40 %
initial indicators of blood flow according to MCA				
Vps (cm/s)	54,2±3,2	56,7±5,6	49,3±6,7	75,3±8,4**
TAMX (cm/s)	37,6±7,63	36,5±4,7	29,6±2,4	42,8±4,3**
indicators of blood flow according to MCA after a breath-holding test				
Vps (cm/s)	76,2±12,2**	76,2±12,2**	76,2±12,2**	96,2±10,61*
TAMX (cm/s)	38,2±4,9**	38,2±4,9**	38,2±4,9**	57,02±11,2*
RI	0,51±0,10**	0,51±0,10**	0,51±0,10**	0,55±0,09*

Note: CCA - common carotid artery; CFA – common femoral artery; MCA – middle cerebral artery; Vps – peak systolic blood flow rate; TAMX – time-averaged maximum blood flow rate; RI - peripheral resistance index; * – p<0.05 – reliability of differences between the indicators obtained initially and after the sample; ** – p<0.05 – the difference is significant between the indicators when compared with group 4. (comparison group)

The thickness of the CMM in patients of group 1 in the OSA was 1.32±0.07 mm, in the common femoral artery (BOTH) – 1.24±0.06 mm, the numerical values of these indicators are higher than similar indicators in patients of comparison group 4, p<0.05

, the thickness of the CMM in patients of group 2 in the OSA was 1.28±0.03 mm, in the common femoral arteries (BOTH) – 1.20±0.05 mm, numerical values of these indicators are higher than similar indicators in patients of comparison group 4, p<0.05

The thickness of the CMM in patients of group 3 in the OSA was 2.46±0.02 mm, in the common femoral artery (BOTH) – 2.42±0.07 mm, the numerical values of these indicators are higher than similar indicators in patients of comparison group 4, p<0.05

, the thickness of the CMM in patients of group 4 in the OSA was 1.18±0.09 mm, in the common femoral arteries (BOTH) -1.12±0.08mm, numerical values of these indicators differed unreliably from similar indicators in the norm, p >0.05

When performing a qualitative analysis of the state of the CMM in patients of the main groups with DM 2, various changes were revealed: diffuse thickening of the CMM with the appearance of additional layers of increased and decreased echogenicity of BOTH, the superficial femoral artery (PUB), popliteal artery (PKA), posterior tibial artery (ZBBA) and anterior tibial artery in the structure of intima-media arteries (PBBA) – 100% of cases; in the common carotid artery (CCA) – 95%; the presence of multiple local zones of increased echogenicity in the structure of CMM with visualization of atherosclerotic plaques (in ZBBA and PBBA – in 95% of patients, in PKA – in 80%, in BOTH and PUB – in 71.7%; in OCA – in 66.7% of patients), increased echogenicity of CMM with complete loss of its differentiation into layers (in OCA – in 13% of cases).

In patients of the IHD comparison group without DM2, changes in the intima-media complex were found mainly in the main vessels in the form of diffuse uneven thickening with increased echogenicity, in places with loss of differentiation into layers (OSA - in 55.9%, BOTH and PUB – in 70.6%, PKA – in 54.4%, ZBBA and PBBA – in 45.6%) and the presence of atherosclerotic plaques (OCA – in 42.6% of cases, BOTH and PUB – in 57.4%).

In the main 3 groups of patients with type 2 diabetes, during metabolic stimulation of the endothelium of SMA, a negative response was obtained in 38 out of 45 patients (84.4%) of the patient, in 7 (15.5%) patients – a paradoxical SMA response.

In group 4 (comparison group), when assessing cerebrovascular reactivity, reliable dynamics of the peak systolic blood flow rate of SMA up to 14%, the time-averaged maximum blood flow rate up to 28% ($p < 0.05$) was obtained. Only 6 (40%) patients had a negative SMA reaction.

Thus, the performed studies have shown that in patients with CHD with type 2 diabetes, changes occur in the peripheral vessels that have a bilateral and diffuse character, while in patients with CHD without type 2 diabetes, changes in the peripheral arteries were usually unilateral with pathology of a single segment of the arterial tree.

The next step of our study was to study the structural and functional parameters of the heart in patients (Table 6). Table 6

Indicators of structural and functional parameters of the heart in patients included in the study ($M \pm m$)

Indicator	1 gr N=21	2 gr N= 18	3 gr N=16	4 gr N=15	p
SBP, mmHg.	154,3±12	167,5±15	156,9±14	167,5±16	<0,05
DBP, mmHg.	93,3±13,2	94,5±11,6	98,8±12,8	96,8±13,9	<0,05
Heart rate, beats/min	86,6±12	78,6±13	77,6±11	82,7±12	<0,05
EDS LV, cm	6,8±0,9	6,9±0,4	7,4±0,4	7,2±0,6	<0,05
CSR , ml	26,4±2,9	23,4±2,2	27,6±2,5	21,2±2,6	<0,05
КДО , мл	78,6±8,8	87,2±6,4	77,2±4,2	81,2±5,2	<0,05
КСР ЛЖ, см	3,8±0,7	3,2±0,3	3,4±0,7	3,4±0,7	<0,05
ЛП, см	3,7±0,6	4,8±0,2	4,3±0,7	4,6±0,4	<0,05
ТМЖП, см	1,1±0,2	1,2±2,2	1,1±0,2	0,9±0,02	>0,05
Среднее давление в ЛА, мм рт.ст.	37,8±12,4	34,7±11,2	33,6±10,5	35,3±9,5	<0,05
DT, мсек	228±14,2	228±14,2	210±12,3	212±11,6	<0,001
TZSLJ, cm	0,7±0,03	0,6±0,04	0,9±0,04	0,8±0,06	>0,05
RA, мм	12,3 ± 2,6	11,5 ± 3,1	15,8 ± 3,4	14,2 ± 2,6	>0,05
EF, %	34,5±7,5	44,2±3,1	36,2±5,6	45,6±4,8	<0,05
E/A	0,68±0,7	0,65±0,3	0,79±0,6	0,62±0,8	<0,05
IVRT, msec	98,7±6,6	103,2±9,7	109±10,5	94,3±6,3	<0,05
MMLV, г	149,8±8,6	154,6±10,4	155,8±11,8	150,8±11,1	<0,05
IMMLJ, g/m2	139,6±6,7	142,5±7,4	138,3±5,8	132,4±6,3	<0,05

Note: *The differences are significant, $p < 0.05$, < 0.001 in comparison with the norm, . Abbreviations: DBP — diastolic blood pressure, CDR — the final diastolic size, CSR — the final systolic size, LA — pulmonary artery, LV — left ventricle, LP — left atrium, n/a — an unreliable difference in the compared parameters, RV — right ventricle, SBP —systolic blood pressure, TSSLJ — the thickness of the posterior wall of the left ventricle, TMJP — thickness of the interventricular septum, EF — ejection fraction, CHF — chronic heart failure, heart rate — heart rate, DT — time of slowing of early diastolic blood flow

IVRT is the time of LV isovolumic relaxation, E/A is the ratio of peak wave velocities E and A., KDO is the final diastolic volume, CSR is the final systolic volume,

As can be seen from Table 6, there is a significant difference in the indicators of central hemodynamics in the studied groups compared with the norm: for example, LV CDR, CSR, CDR, LV CSR ($p < 0.05$), data on the average pressure in the pulmonary artery, the time of slowing down the blood flow of early diastolic filling, TSSLJ ($p < 0.001$), PV, the ratio peak velocities of waves E and A, the time of isovolumic relaxation of LV, MMLJ, IMLJ ($p < 0.05$). Thus, significant deviations of Echo-ECG data were found in patients of the studied groups, which requires further study.

CONCLUSION

1. The combined effect of hemodynamic and metabolic disorders has the greatest damaging effect on the endothelium of the arteries. In all patients with type 2 diabetes mellitus in combination with coronary heart disease, dysfunction of the endothelial mechanism of vascular tone regulation was revealed - in 84%.
2. Among the risk factors, hereditary burden of diabetes prevailed - only 21 cases out of 60 (35%), smoking – only 49 cases (81.6%), alcoholism – 16 cases (26.6%).
3. Significant deviations of central hemodynamic parameters were revealed in the studied groups.

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