Psychiatria Danubina, 2025; Vol. 37, Suppl. 1, pp 315-320
Conference paper

Research article

STIFFNESS OF ARTERIES AND LEFT ATRIUM AS PREDICTORS FOR COGNITIVE IMPAIRMENT IN CARDIOLOGY PATIENTS

Olga Germanova[1], Yulia Reshetnikova[1], Ksenia Ermolayeva[1], Oksana Chigareva[2] & Giuseppe Galati[1,3]

[1]International Centre for Education and Research in Cardiovascular Pathology and Cardiovisualization, Samara State Medical University, Samara, Russia
[2]Samara Institute of Mental Health, Medical University "Reaviz", Samara, Russia
[3]I.R.C.C.S. Ospedale Multimedica – Cardiovascular Scientific Institute, Milan, Italy

SUMMARY

Background: *To evaluate the relationship between cognitive function and the data of volumetric sphygmography and speckle tracking echocardiography in patients with heart arrhythmias.*

Materials and methods: *Monocentral cohort study with 33 patients. Group 1 – patients with frequent extrasystoles (ES) of II and more class by Lown (n = 12; 47–79 years old), group 2 - with paroxysmal atrial fibrillation (AF) (n = 14; 50–81 years old) and control group - without serious cardiovascular diseases (n = 7; 46–75 years old). Methods: lipidograms, 24 hours ECG monitoring, TTE, volumetric sphygmography. For cognitive function evaluation, we used the standard MoCA Test.*

Results: *Post hoc analysis according to Dunn showed that groups 1 and 2 differed in LA volume ($p = 0.002$, $\varepsilon^2 = 0.34$) and MoCA ($p = 0.007$, $\varepsilon^2 = 0.30$). Differences between groups 2 and control were also significant for LA volume ($p = 0.024$) and MoCA ($p = 0.045$). We observed a decreasing of cognitive function in both main groups, mostly in with paroxysmal AF. Statistically significant differences in GLS between 1 and 2 group – it was lower in group 2, characterizing the decreasing of LV systolic function.*

Conclusions: *In patients with frequent ES and paroxysmal AF, develop a cognitive impairment, mostly in the group with paroxysmal AF. Increased arterial stiffness parameters (R-CAVI, L-CAVI) and LA structural changes (increased LA volume, decreased LA strain) are significant predictors of cognitive impairment. The group of patients with paroxysmal AF differed most significantly from the control group in all key parameters.*

Key words: *CAVI - cognitive function - heart arrhythmias – left atrial strain – MoCA*

Abbreviations: *ABI - ankle brachial index; AF – atrial fibrillation; CAVI - cardio-ankle vascular index; EchoCG – echocardiography; ES – extrasystoles; GLS - global longitudinal strain; LA – left atrium; LV – left ventricle; LVEF – left ventricle ejection fraction; MoCA - Montreal Cognitive Assessment test; TTE - transthoracic echocardiography; RV – right ventricle; TR – tricuspid regurgitation*

* * * * *

INTRODUCTION

Promising technologies in transthoracic echocardiography (TTE) during the last years help the imagers to evaluate more deeply the heart, in its structural and functional parameters. Tissue strain imaging is a technique in echocardiography (EchoCG) that allows for the quantitative assessment of myocardial strain based on ultrasound strain and strain rate. The strain (ε) value is relative, so it is expressed in %. If the object is lengthened, the strain is positive, if it is shortened, it is negative. The deformation of the myocardium, expressed as a one-dimensional object, is designated as strain (ε). The strain can be calculated throughout the entire cardiac cycle if the initial length of the myocardial segment being studied is known. The strain reflects the total deformation during the cardiac cycle relative to the initial length (the length at the beginning of the cardiac cycle) (Badano et al. 2018, Galderisi et al. 2017). In the method of left atrium (LA) strain evaluation, there are three main parameters: LA reservoir strain (total, general), LA conduit strain (positive, early diastolic), LA contractile (pump) strain (negative, late diastolic) (Robinson et al. 2024).

Sphygmography is the method of non-invasive evaluation of arterial stiffness parameters in different diseases. It was actively used in the 1980s. The current publications, since 2006, use evaluation the CAVI parameter, which reflects the rigidity of the aorta and its branches, and does not depend on arterial pressure (Shirai et al. 2006). Currently, this parameter is included in the concept of the so-called "vascular age" and serves as an additional marker of the severity of systemic atherosclerosis. In our previous publications, we used the data of sphygmography in arterial function evaluation in heart failure, extrasystolic arrhythmia, atrial fibrillation (AF) (Galati et al. 2022, Germanova et al. 2020, 2022, 2023). However, it is still not studied the dependence between cognitive impairment and main parameters of sphygmography and speckle tracking EchoCG in patients with heart arrhythmias.

Aim of investigation is to evaluate the relationship between cognitive function and the data of volumetric sphygmography and speckle tracking echocardiography in patients with heart arrhythmias.

MATERIALS AND METHODS

We performed monocentral cohort study with participation of 33 patients. Group 1 – patients with frequent extrasystoles (ES) of II and more class by Lown (n = 12; 1 men, 11 women; 47–79 years old), group 2 - with paroxysmal atrial fibrillation (AF) (n = 14; 4 men, 10 women; 50–81 years old) and a control group - without serious cardiovascular diseases (n = 7; 5 men, 2 women; 46–75 years old). Patients were selected from January to August 2024 at Samara state medical university clinics. All patients were asymptomatic in clinical manifestations of heart arrhythmias. Exclusion criteria: chronic heart failure NYHA III–IV, history of stroke, dementia, serious somatic and mental illnesses. Written informed consent was obtained from all participants prior to enrollment in the study. Laboratory and instrumental methods included standard investigations: lipidograms, 24 hours ECG monitoring, TTE, volumetric sphygmography.

All patients underwent EchoCG with additional speckle tracking analysis of parameters of left ventricle global longitudinal strain (GLS), LA reservoir strain, LA conduit strain, LA pump strain. Speckle tracking was performed in an automatic mode with manual correction on Philips EpicCVx echo machine. Normal GLS was 20% and more, normal LA strain parameters varied due to the gender and age and were normalized due to the current ESC clinical recommendations. In TTE protocol, we followed the current clinical standards (Badano et al. 2018). We followed the main principles for more accurate calculation of speckle tracking data: good quality of image; minimal sector of width and depth; high-quality visualization of the endocardium; recording ECG for at least 3 cycles; the patient was holding his breath; required images were - apical long axis, apical 4 chamber, apical 2 chamber; if it was possible, we used the same R-R interval; frame rate in recording was ~ 60-90 fps. The limitations of the method were: arrhythmia bigeminy type; suboptimal visualization.

The parameters of volumetric sphygmography included international CAVI index - of the right (R-CAVI) and left (L-CAVI) extremities. For the evaluation, we used Fukuda VaSera 1500N sphygmograph (Japan); vascular lesions were considered if the ABI value was <0.9. The CAVI data from the patients was analyzed automatically in the up to the age and gender (program VSS-10, S/№50000246).

For cognitive function evaluation, we used the standard MoCA Test validated and translated for the Russian Federation. The interpretation of the results was the following: normal result – 28-30 points; mild cognitive impairment – 22-27 points; moderate cognitive impairment – 10-21 points; severe cognitive impairment – 0-9 points.

We followed the principles of evidence-based medicine. The study was performed in accordance with the principles of the Declaration of Helsinki. The research protocol was approved by the Ethics Committee of Samara State medical university. In statistical analysis, between-group comparisons were performed using one-way ANOVA for normal data followed by Tukey post hoc or Kruskal–Wallis test with Dunn post hoc for non-normal distributions. Post hoc significance was set at $p < 0.05$. Effect size was expressed as η^2 for ANOVA and ε^2 for non-normal test. Correlations between MoCA and indices (R-CAVI, L-CAVI, LA strain) were assessed using Spearman. In our work, we used statistical programs R 4.1 and SPSS 27.

RESULTS

Table 1 demonstrates the main characteristics of the groups, including arterial stiffness and LA parameters.

Post hoc analysis according to Dunn showed that groups 1 and 2 differed in LA volume ($p = 0.002$, $\varepsilon^2 = 0.34$) and MoCA ($p = 0.007$, $\varepsilon^2 = 0.30$). Differences between groups 2 and control were also significant for LA volume ($p = 0.024$) and MoCA ($p = 0.045$). We observed a decreasing of cognitive function in both main groups with patients with heart arrhythmias, mostly in group 2 – with paroxysmal AF (Figure 1).

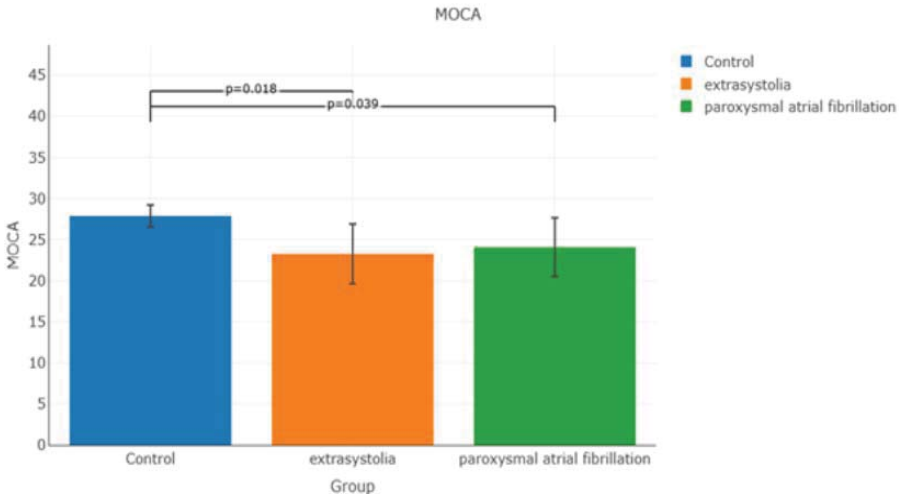

Figure 1. MoCA within the groups

Table 1. Characteristics of included studies on the VR/AR technologies for children and adolescents with high-functioning ASD

	Control (n=7)	Group 1 (n=12)	Group 2 (n=14)	Total (n=33)	Normality test	Test	Effect size	Control vs 1	Control vs 2	1 vs 2
Age Mean ± SD	55.71 ± 14.24	56.25 ± 14.40	64.64 ± 10.09	59.70 ± 13.01	p = 0.054	F(2, 30) = 1.85, p = 0.174	η^2 = 0.110	0.475	0.141	0.117
BMI Mean ± SD	31.96 ± 7.30	28.93 ± 5.55	30.63 ± 5.24	30.29 ± 5.75	p = 0.242	F(2, 30) = 0.64, p = 0.536	η^2 = 0.041	0.220	0.364	0.300
R-CAVI Mean ± SD	7.20 ± 1.85	7.73 ± 1.50	8.21 ± 2.03	7.82 ± 1.80	p = 0.434	F(2, 30) = 0.76, p = 0.479	η^2 = 0.048	0.334	0.197	0.314
L-CAVI Mean ± SD	7.23 ± 1.90	7.60 ± 1.17	8.26 ± 1.89	7.80 ± 1.67	p = 0.300	F(2, 30) = 1.02, p = 0.372	η^2 = 0.064	0.370	0.173	0.240
R-ABI Median [Q1; Q3]	1.13 [1.08; 1.25]	1.10 [1.03; 1.13]	1.10 [1.03; 1.11]	1.10 [1.04; 1.13]	p = 0.037	H(2) = 1.93, p = 0.382	ε^2 = 0.060	0.664	0.588	1.000
L-ABI Mean ± SD	1.09 ± 0.12	1.04 ± 0.15	1.11 ± 0.09	1.08 ± 0.12	p = 0.129	F(2, 30) = 1.14, p = 0.333	η^2 = 0.071	0.250	0.423	0.148
MoCA *Mean ± SD*	*27.86 ± 1.35*	*23.25 ± 3.65*	*24.07 ± 3.56*	*24.58 ± 3.63*	*p = 0.398*	*F(2, 30) = 4.66, p = 0.017*	*η^2 = 0.237*	*0.018**	*0.039**	*0.326*
LVEF% Mean ± SD	60.29 ± 3.04	62.33 ± 3.14	60.57 ± 3.08	61.15 ± 3.13	p = 0.093	F(2, 30) = 1.39, p = 0.264	η^2 = 0.085	0.163	0.444	0.153
GLS% *Mean ± SD*	*21.33 ± 2.57*	*22.25 ± 2.18*	*18.95 ± 2.98*	*20.65 ± 2.97*	*p = 0.229*	*F(2, 30) = 5.39, p = 0.010*	*η^2 = 0.264*	*0.301*	*0.083*	*0.012**
LA reservoir strain % Median [Q1; Q3]	28.00 [24.50; 49.00]	34.50 [29.50; 42.25]	23.90 [20.00; 35.25]	30.00 [22.00; 37.40]	p = 0.005	H(2) = 4.89, p = 0.087	ε^2 = 0.153	1.000	0.834	0.084
LA conduit strain % Mean ± SD	24.29 ± 16.14	22.08 ± 10.62	17.66 ± 7.10	20.67 ± 10.76	p = 0.125	F(2, 30) = 1.05, p = 0.362	η^2 = 0.066	0.380	0.173	0.229
LA pump strain % Mean ± SD	13.57 ± 6.53	13.50 ± 6.10	10.31 ± 3.81	12.16 ± 5.41	p = 0.145	F(2, 30) = 1.46, p = 0.248	η^2 = 0.089	0.492	0.176	0.142
RV free wall strain % Mean ± SD	27.83 ± 8.80	28.33 ± 6.49	23.09 ± 7.22	26.40 ± 7.48	p = 0.803	F(2, 26) = 1.57, p = 0.227	η^2 = 0.108	0.459	0.177	0.119
LA volume ml *Median [Q1; Q3]*	*55.00* *[40.50; 69.00]*	*51.00* *[49.50; 56.75]*	*65.70* *[56.45; 92.10]*	*56.00* *[51.00; 71.00]*	*p = 0.048*	*H(2) = 6.71, p = 0.035*	*ε^2 = 0.209*	*1.000*	*0.348*	*0.036**
LA indexed volume ml/m^2 Median [Q1; Q3]	27.00 [23.00; 28.00]	27.50 [24.00; 31.50]	34.70 [30.35; 40.97]	29.00 [26.00; 36.70]	p = 0.048	H(2) = 7.27, p = 0.026	ε^2 = 0.227	1.000	0.062	0.087
E/A Mean ± SD	1.24 ± 0.23	1.07 ± 0.41	1.01 ± 0.30	1.08 ± 0.34	p = 0.090	F(2, 29) = 1.11, p = 0.343	η^2 = 0.071	0.221	0.148	0.378
E/e' Mean ± SD	6.86 ± 1.68	7.42 ± 1.95	8.09 ± 1.92	7.59 ± 1.89	p = 0.145	F(2, 30) = 1.07, p = 0.357	η^2 = 0.066	0.327	0.159	0.263
TR speed, m/sec *Mean ± SD*	*2.15 ± 0.35*	*2.38 ± 0.21*	*2.58 ± 0.40*	*2.42 ± 0.36*	*p = 0.122*	*F(2, 30) = 4.11, p = 0.026*	*η^2 = 0.215*	*0.149*	*0.023**	*0.137*
LV relative thickness Median [Q1; Q3]	0.36 [0.28; 0.41]	0.33 [0.28; 0.37]	0.39 [0.35; 0.42]	0.35 [0.32; 0.42]	p < 0.001	H(2) = 3.65, p = 0.161	ε^2 = 0.114	1.000	0.704	0.196
LV indexed mass g/m^2 *Mean ± SD*	*60.57 ± 21.39*	*62.00 ± 18.31*	*80.43 ± 14.97*	*69.52 ± 19.57*	*p = 0.572*	*F(2, 30) = 4.66, p = 0.017*	*η^2 = 0.237*	*0.452*	*0.043**	*0.030**
Gender n (%) Female Male	 2 (28.57%) 5 (71.43%)	 11 (91.67%) 1 (8.33%)	 10 (71.43%) 4 (28.57%)	 23 (69.70%) 10 (30.30%)	-	χ^2(2) = 8.37*, p = 0.015	Cramer's V = 0.504	-	-	-

Notes: * statistically significant data; LVEF – left ventricle ejection fraction; LV – left ventricle; LA – left atrium; RV – right ventricle; TR – tricuspid regurgitation; GLS – global longitudinal strain

In addition, we observed statistically significant differences in GLS between 1 and 2 group – with ES and paroxysmal AF – this parameter was lower in group 2, characterizing the decreasing of LV systolic function (Figure 2).

Table 2 shows the Spearman correlation coefficients between MoCA and key parameters.

Figure 3 demonstrates the correlation between MoCA and R-CAVI parameter.

Table 2. Correlations of MoCA with arterial stiffness and LA parameters (n = 33)

Parameter	rs	95% CI	p
R-CAVI	–0.411	[–0.695; –0.016]	0.037
L-CAVI	–0.434	[–0.709; –0.044]	0.027
LA volume	–0.482	[–0.733; –0.146]	0.006
LA reservoir strain	0.528	[0.209; 0.757]	0.002

Pair	Spearman's rs	95% CI		p-value
MoCA, Age	-0.229	-0.574	to 0.186	0.26076
MoCA, LA reservoir strain %	0.117	-0.294	to 0.492	0.56928
MoCA, LA conduit strain %	-0.106	-0.483	to 0.304	0.60558
MoCA, LA pump strain %	0.195	-0.219	to 0.550	0.33897
MoCA, RV strain %	0.051	-0.390	to 0.473	0.82153
MoCA, LV volume ml	-0.098	-0.477	to 0.312	0.63428
MoCA, LV indexed volume ml/m^2	-0.128	-0.500	to 0.284	0.53301
MoCA, E/A	-0.022	-0.424	to 0.387	0.91788
MoCA, E/e'	-0.154	-0.520	to 0.259	0.45134
MoCA, TR speed, m/sec	0.152	-0.261	to 0.519	0.45750
MoCA, LV relative thickness	-0.049	-0.438	to 0.355	0.81113
MoCA, LV indexed mass g/m^2	-0.188	-0.545	to 0.227	0.35843

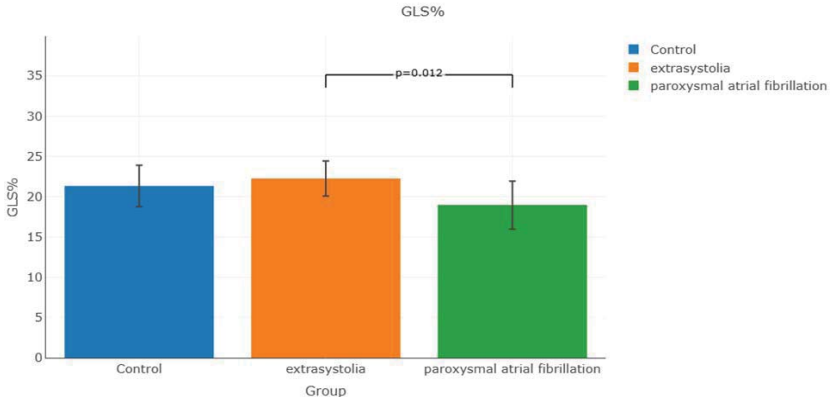

Figure 2. GLS (%) between the groups

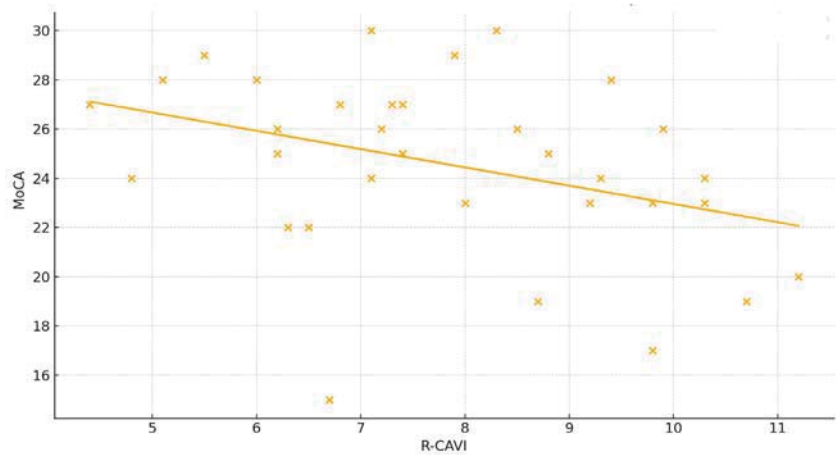

Figure 3. Correlation of MoCA score and R-CAVI. Scatter plot with regression line

The results demonstrate that increased arterial stiffness (R-CAVI, L-CAVI) and LA structural changes (increased LA volume, decreased LA strain) are significant predictors of cognitive impairment. The group of patients with paroxysmal AF (group 2) differed most significantly from the control group in all key parameters.

DISCUSSION

Arrhythmias, such as ES and AF, remaining the problem for millions of people all over the world, being one the most frequent kinds of cardiological pathologies (Al-Khatib SM et al. 2018, Joglar JA et al. 2024). Many complaints are associated with the sensation of palpitations, "stopping the heart", cardiophobia, that makes this problem multidisciplinary, because in some cases for the primary visit the patients goes to get the consultation of psychotherapist. Frequent ES and AF, especially with RR intervals on ECG 1,5 seconds and more are associated with the higher level of cardiovascular complications (stroke, transient ischemic attack, myocardial infarction, distal arterial embolisms of the other basins) (Germanova O et al. 2020, 2022, 2023). The risk of these complications does not differ in patients who are asymptomatic in heart arrhythmias. Moreover, being asymptomatic and less examined, they remain without proper antiarrhythmic therapy, which increases the risk of cardiovascular complications in this category of patients. Asymptomatic patients undergo the structural changes in the heart chambers that lead to the progression of fibrosis and appearance of more severe arrhythmias.

From the other side, within the routine investigation of EchoCG during the last years it is more often performed the new modes – speckle tracking of the LV, LA and RV. In the last recommendations of the British Society of Echocardiography, LA strain is within the recommended methods of the routine LV diastolic function evaluation and an additional instrument of non-invasive research of structural changes (including fibrosis) of the LA (Robinson et al. 2024). Chronic ischemia, hemodynamic changes and microcirculation disturbances, associated with heart arrhythmias, especially frequent ES and paroxysmal AF, can lead to the cognitive impairment in the long-term period, as we revealed in our research. The results of our study demonstrate that increased arterial stiffness measured by volumetric sphygmography (R-CAVI, L-CAVI) and LA structural changes (increased LA volume, decreased LA strain) appeared the significant predictors of cognitive impairment, especially in the group of patients with paroxysmal AF that differed most significantly in all key parameters from the control group.

Early detection of heart arrhythmias, timely correction of treatment and prescription of antiarrhythmic therapy, as well as the use of new promising diagnostic methods (such as speckle tracking EchoCG, CAVI indication with "vascular age" detection) will improve the prognosis in cognitive function and quality of life of this category of patients.

CONCLUSIONS

- In patients with frequent ES and paroxysmal AF, develop a cognitive impairment, mostly in the group with paroxysmal AF.
- Increased arterial stiffness parameters (R-CAVI, L-CAVI) and LA structural changes (increased LA volume, decreased LA strain) are significant predictors of cognitive impairment. The group of patients with paroxysmal AF (group 2) differed most significantly from the control group in all key parameters.

Acknowledgements:

We express our sincere gratitude to Professor Paul Cumming of Bern University, Bern, Switzerland, for language review of the manuscript and valuable commentaries.

Conflict of interest: *None to declare.*

Contribution of individual authors:

Olga Germanova, Yulia Reshetnikova & Ksenia Ermolayeva: search and analysis of literature, collection of clinical data, data interpretation, writing the first draft.

Oksana Chigareva & Giuseppe Galati: search and analysis of literature, data interpretation, and editing.

All authors approved the final version of the article before its submission.

References

1. *Al-Khatib SM, Stevenson WG, Ackerman MJ, Bryant WJ, Callans DJ, Curtis AB et al.: 2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society. J Am Coll Cardiol. 2018 Oct 2;72(14):e91-e220. doi: 10.1016/j.jacc.2017.10.054.*
2. *Badano LP, Kolias TJ, Muraru D, Abraham TP, Aurigemma G, Edvardsen T et al.: Standardization of left atrial, right ventricular, and right atrial deformation imaging using two-dimensional speckle tracking echocardiography: a consensus document of the EACVI/ASE/Industry Task Force to standardize deformation imaging. Eur Heart J Cardiovasc Imaging. 2018 Jun 1;19(6):591-600. doi: 10.1093/ehjci/jey042. Erratum in: Eur Heart J Cardiovasc Imaging. 2018 Jul 1; 19(7):830-833. doi:10.1093/ehjci/jey071.*

3. *Galderisi M, Cosyns B, Edvardsen T, Cardim N, Delgado V, Di Salvo G et al.: 2016–2018 EACVI Scientific Documents Committee & 2016–2018 EACVI Scientific Documents Committee: Standardization of adult transthoracic echocardiography reporting in agreement with recent chamber quantification, diastolic function, and heart valve disease recommendations: an expert consensus document of the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging. 2017 Dec 1; 18(12):1301-1310. doi: 10.1093/ehjci/jex244.*
4. *Galati G, Germanova O, Iozzo RV, Buraschi S, Shchukin YV, Germanov A et al.: Hemodynamic arterial changes in heart failure: a proposed new paradigm of "heart and vessels failure". Minerva Cardiol Angiol. 2022 Jun; 70(3):310-320. doi: 10.23736/S2724-5683.21.05786-0.*
5. *Germanova O, Galati G, Germanov A & Stefanidis A: Atrial fibrillation as a new independent risk factor for thromboembolic events: hemodynamics and vascular consequence of long ventricular pauses. Minerva Cardiol Angiol. 2023 Apr;71(2):175-181. doi: 10.23736/S2724-5683.22.06000-8.*
6. *Germanova O, Smirnova D, Usenova A, Tavormina G, Cumming P & Galati G: Cryptogenic Stroke In The Context of Pandemic-Related Stress: The Role of Arterial Hemodynamics. Psychiatr Danub 2022; 34(Suppl 8):256-261*
7. *Germanova OA, Germanov AV, Galati G, Prokhorenko IO & Germanov VA: Cryptogenic stroke in atrial fibrillation without intra-heart thrombi: possible mechanisms. Bulletin of the Medical Institute "REAVIZ" (Rehabilitation, Doctor And Health). 2022;12(2):80-89. doi: 10.20340/vmi-rvz.2022.2.CLIN.7*
8. *Germanov AV, Germanova OA, Germanov VA & Prokhorenko IO: Atrial fibrillation: functional classification. Bulletin of the Medical Institute "REAVIZ" (Rehabilitation, Doctor and Health). 2020;(2):129-134.*
9. *Germanova OA, Germanov VA, Shchukin YuV, Germanov AV & Piskunov MV: Extrasystoles: adverse effects of the first postextrasystolic contraction. Bulletin of the Medical Institute Reaviz. Rehabilitation, Doctor and Health. 2020; 6(48):89–97. https://doi.org/10.20340/vmi-rvz.2020.6.11.*
10. *Germanova OA, Germanov AV & Shchukin YuV: Extrasystoles: relationship with arterial thromboembolic complications. Science and Innovations in Medicine. 2022; 7(3):164-169. doi: 10.35693/2500-1388-2022-7-3-164-169.*
11. *Joglar JA, Chung MK, Armbruster AL, Benjamin EJ, Chyou JY, Cronin EM et al.: 2023 ACC/AHA/ACCP/HRS Guideline for the Diagnosis and Management of Atrial Fibrillation: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. Circulation. 2024 Jan 2;149(1):e1-e156. doi: 10.1161/CIR.0000000000001193.*
12. *Robinson S, Ring L, Oxborough D, Harkness A, Bennett S, Rana B et al.: The assessment of left ventricular diastolic function: guidance and recommendations from the British Society of Echocardiography. Echo Res Pract 2024; 11:16. doi: 10.1186/s44156-024-00051-2*
13. *Shirai K, Utino J, Otsuka K & Takata M: A novel blood pressure-independent arterial wall stiffness parameter; cardio-ankle vascular index (CAVI). J Atheroscler Thromb 2006; 13:101-7. doi: 10.5551/jat.13.101*

Correspondence:
Olga Germanova, MD, PhD
International Centre for Education and Research in Cardiovascular Pathology and Cardiovisualization, Samara State Medical University
18 Gagarina Street, 443096 Samara, Russia
E-mail: olga_germ@mail.ru