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Heart Rate Variability Analysis Before and During Coronary Artery Bypass Graft Surgery

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Abstract

The purpose of these researches was evaluation of the high-resolution Rhythm Cardiography (ECG) possibilities for definition of an actual cardiovascular status of the operated patients with angina pectoris during carrying out of the Coronary Artery Bypass Graft Surgery (CABGS) for a myocardial revascularization. These investigations were made out by means of the hardware-software complex KAP-RC-02 -"Micor" with a monitor record and the analyses of the Heart Rate Variability (HRV) in Time-Domain and Frequency-Domain. Monitor records were made in various stages CABGS in 123 patients. In results, the RCG manifested oneself as the quite adequate and perspective method of the definition of the actual cardiovascular status during carry out for cardiac revascularization in patients with angina pectoris. Also the data of the HRV studying at the CABGS testify about possibilities of the RCG definition of the high risk of life-dangerous cardio arrhythmias during operation, about different changes of the Sinoatrial heart Node (SN) regulation, and concerning the symptoms of the lethal outcome of CABGS. The loss of the peripheral autonomic sympathetic and parasympathetic control in SN in the form of an autonomic cardioneuropathy syndrome is the predictor of the intraoperative complications during and after CABGS. The obtained data at the RCG monitoring HRV record assume about wide prospects of the high-resolution RCG using in the cardiac surgery as a whole. Actual multiple deregulations of SN pacemaker activity testified to its adequate to a pathophysiology of each period of this cardiac operation, according to initial ischemic defeats and localization of the cardiosurgical manipulations during CABGS.

Keywords: Heart rate variability; Coronary artery bypass graft surgery; Actual cardiovascular status; Predictors of complications; Lethal outcome

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Introduction

The purpose of researches was evaluation of possibilities of the high-resolution Rhythm Cardiography (ECG) for the Heart Rate Variability (HRV) analysis and definition of actual cardiovascular status in patients (pts) with angina pectoris during the Coronary Artery Bypass Graft Surgery (CABGS). This purpose was obtained by the assumption that at cardiological surgery, as well as at cardiology [1-3], the RCG analysis of the HRV for definition of deregulations at coronary artery disease may be useful actual diagnosis of the intraoperative cardiovascular status. Earlier researches on this subject had no convincing results [4]. This, we assume, was connected with insufficient results at low sensitivity of the HRV registration, and also with ignoring of a humoral-metabolic influence on the autonomic regulation of the pacemaker activity of the SN [4-8]. Innovative contemporaneous achievements in the HRV registration and analysis are especially important for identification of predictors and markers of the intraoperative complications [9,10], including life-threatening cardio arrhythmias [7,11,12].

Material and Methods

Standard cardiological researches were made out before cardiosurgical operation of 256 pts. After initial standard and RCG investigations there were selected 123 pts for CABGS. Healthy 47 men's were control (Figure 1). 123 pts were investigated for HRV analysis by the specialized computer diagnostic complex CAP-RC-01-"Micor". Initially additional RCG-symptoms, characteristic for stable angina pectoris, were defined at the intranozological diagnostics of the Coronary Artery Disease (CAD) before operation. In patients was made out CABGS on open heart with an it's

Table 1: HRV-indices before (n-123) and after (n-123) premedication at the CABGS.

HRV indices	RR s	SDNN s,	σl, s	σm, s	σs, s	VLF%	LF%	HF%
(M ± σ) in seconds (s) and %. Criterions Z and p	average quadratic deviation o of RR-intervals	average quadratic deviation of all HRV waves	average quadratic deviation of humoral HRV waves	average quadratic deviation of sympathetic HRV waves	average quadratic deviation of parasympathetic HRV waves	Spectral share of humoral HRV waves	Spectral share of sympathetic HRV waves	Spectral share of parasympathetic HRV waves
HRV–in-dices before CABS	0.984 ± 0.144	0.024 ± 0.009	0.018 ± 0.008	0.011 ± 0.005	0.011 ± 0.008	56.39 ± 14.9	17.84 ± 10.83	25.76 ± 12.53
HRV –in- dices after pre-medication	0.522 ± 0.031	0.011 ± 0.002	0.002 ± 0.001	0.001 ± 0.0012	0.002 ± 0.001	68.8 ± 8.42	15.23 ± 6.11	15.7 ± 4.78
Z* P	34.7 p<0.0001	6.5 p<0.01	1.45 p>0.05	4.01 p<0.05	12.8 p<0.001	7.892 p<0.01	2.1 p<0.05	6.89 p<0.01

*Here was used criterion Z for data of large volume. (Reliability must be at Z more 1,9)

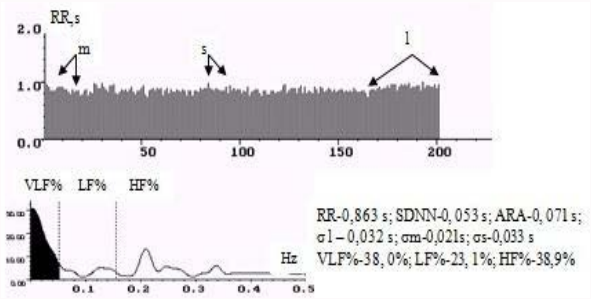

Figure 1: Rhythmocaridogram, spectrogram and middle values of RCG-signs of healthy man.

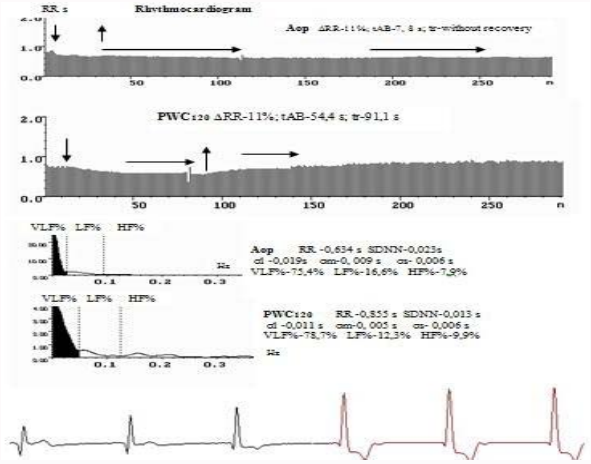

Figure 2: Here are Rhythmocaridogram, spectrogram and middle values of the HRV indices of a patient with stable angima pectoris 2FC in Aop and PWC120 tests.

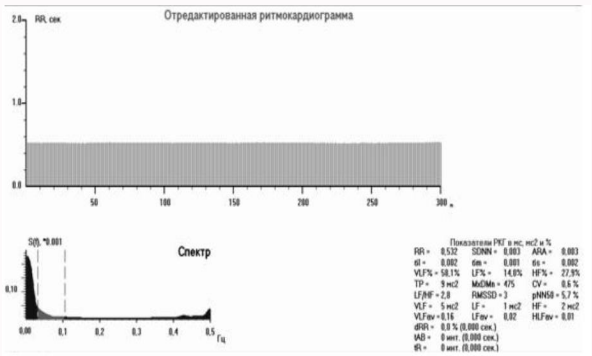

Figure 3: Here are Rcg and spectrogram and middle HRV –indices after a premedication.

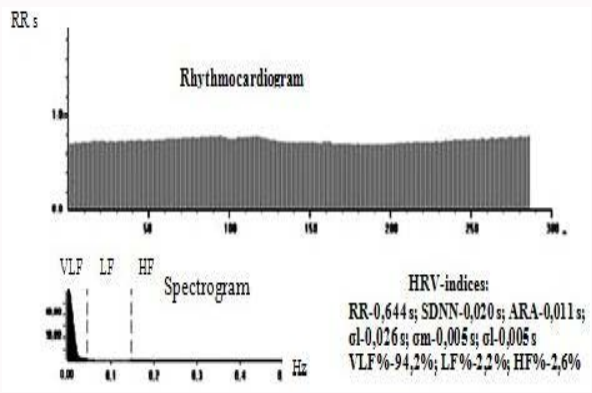

Figure 4: Rcg, spectrogram and middle value of the HRV –indices at the intubation nacrosis.

stop and passage to an apparatus of artificial blood circulation (ABC) by use of the cardiopulmonary pump. HRV was recorded during CABGS by the specialized hardware-software diagnostic complex CAP-RC-02-"Micor" of high-resolution (discretization of ECG-signal (1000 ± 3Hz) at the monitor record (The certificate No. FS 02262005/2447-06; patent No 2199945). In the software at RCG-research HRV analyses were made out in Time-Domain and Frequency-Domain with using of the Fast Fourier's transformation and Parsen's and Hamming's spectral windows. Basic HRV-indices were considered: RR-average value of the all intrasystole intervals, their standard deviation – SDNN, average square deviations of the humoral -metabolic (σl), sympathetic – (σm) and parasympathetic – (σs) amplitudes of HRV-fluctuations. Also the spectral analysis was calculated for evaluation of correlation of regulative factors influences in the sinoatrial heart node (SN) - VLF%, LF%, HF% (Figure 1-7). The monitor Rhythmocardiogram record (Rcg) was remotely transferred to neurocardiology laboratory for the immediate analysis and recommendations to cardiac anesthesiologists. HRV registration was carried out till and after cardiac arrest and at the passage of the blood circulation to apparatus blood circulation-ABC. At the same time with Rcg record in real current time the Electro Cardio Gram (ECG) was registered too. Before shunting HRV researches were made out in rest (Ph) and 4 tests. After a premedication narcosis. The monitor Rcg was registered without tests. Rcg is a graphic image of intersystole pauses between heart contractions, as the vertical rectilinear pieces, equivalent in size of RR intervals duration with the beginning on abscissa axis and as parallel to ordinate axis (Figure 1-12). The intervals were registered during of all CABGS till the passage to ABC and after ABC. Every period of CABGS had itself peculiarities of HRV wave structure. Every Rcg consists of 300 RR- intervals. The artifacts were caused by influence of the electric knife, direct surgical

Table 2: Results of HRV comparison in patients with autonomic cardioneuropathy (ACN) (n-56, first line) and in patients without ACN (n-67, second line) before CABGS.

HRV indices (M ± σ) in sec. (s) and %	Ph, Initial posture	Vm, manoeuvre	pA, Ashner test	Aop, Active ortos-tatic test	PWC_{120} Exercise test
RR s, average interval	0.522 ± 0.081 0.768 ± 0.114 **t=14.05*****	0.542 ± 0.072 0.770 ± 0.102 **t=14.61*****	0.46 ± 0.082 0.77 ± 0.07 **t=13.83****	0.698 ± 0.95 0.810 ± 0.087 **t=7.25****	0. 783 ± 0,124 0.730 ± 0.074 **t=2.83***
SDNN s, average dispersion of all HRV waves	0.011 ± 0.002 0.017 ± 0.006 **t=2.0***	0.011 ± 0.005 0.016 ± 0.005 **t=5.98****	0.011 ± 0.006 0.017 ± 0.004 **t=7.79****	0.009 ± 0.004 0.017 ± 0.006 **t=8.88*****	0.010 ± 0.005 0.018 ± 0.004 **t=10.3*****
σl, s average quadratic dispersion of humoral waves	0.002 ± 0.001 0.008 ± 0.004 **t=10.0*****	0.008 ± 0.004 0.011 ± 0.005 **t=4. 28***	0.008 ± 0.004 0.012 ± 0.005 **t=5.19****	0.007 ± 0.003 0.012 ± 0.04 **t=8.33*****	0.008 ± 0.003 0.015 ± 0.004 **t=11.6*****
σm, s average quadratic of sympathetic HRV waves	0.001 ± 0.001 0.006 ± 0.002 **t=6.02****	0.04 ± 0.002 0.008 ± 0.002 **t=4.0****	0.004 ± 0.002 0.009 ± 0.003 **t=3.57***	0.003 ± 0.002 0.009 ± 0.002 **t=5.45****	0.005 ± 0.003 0.012 ± 0.002 **t=8.49*****
σs, s average quadratic dispersion of parasympathetic HRV waves	0.002 ± 0.001 0.007 ± 0.004 **t=7.93****	0.006 ± 0.03 0.011 ± 0.003 **t=4.54****	0.006 ± 0. 004 0.010 ± 0.001 **t=6.34****	0.004 ± 0.003 0.012 ± 0.001 **t=16.0*****	0.007 ± 0.005 0.014 ± 0.003 **t=5.38****
VLF% spectral share of humo-ral HRVwaves	78.8 ± 8.42 56.39 ± 14.89 **t=10.47*****	74.64 ± 8.34 60.26 ± 16.30 **t=6.3****	76.19 ± 9.98 55.31 ± 16.42 **t=8.66*****	77.20 ± 19.64 59.36 ± 16.23 **t=5.42****	78.46 ± 24.39 57.87 ± 19.35 **t=5.11***
LF% spectral share of sym-pathetic HRVwaves.	12.33 ± 7.03 17.84 ± 10.83 **t=3.39***	13.77 ± 8.99 16.60 ± 5.82 **t=2.02***	13.98 ± 8.88 17.75 ± 10.0 **t=2.21***	12.89 ± 7.32 18.91 ± 14.22 **t= 3.02***	14.87 ± 6.98 16.64 ± 7.79 **t=1.33**
HF% spectral share of para-sympathetic HRVwaves.	15.7 ± 4.78 25.76 ± 12.53 **t=6.03****	16.58 ± 7.84 21.12 ± 16.18 **t=2.028***	16.88 ± 7.61 20.93 ± 12.7 **t=2.19***	17.9 ± 6.31 22.72 ± 11.24 **t=2.88***	22. 66 ± 7.11 37.48 ± 19.12 **t=5.87****
Δ **RR %** maximal reac-tions in tests.		6.48 ± 6.13 11.59 ± 9.96 **t=3.48***	4.12 ± 3.60 7.95 ± 6.87 **t=3.95***	12.31 ± 6.78 21.69 ± 8.07 **t=6.91****	9.62 ± 7.21 19.23 ± 11.26 **t=5.72****
$t_{AB,}$ s time of maximal reac-tions in tests.		9.92 ± 2.56 7.78 ± 2.58 **t=4.6****	9.38 ± 2.47 5.55 ± 2.38 **t=8.71*****	18.61 ± 6.39 11.99 ± 3.82 **t=6.8****	43.85 ± 12.96 20.0 ± 12.16 **t=10.45*****
$t_{r,}$ s s time of restoration after tests.		12.73 ± 8.61 7.48 ± 4.71 **t=4.07***	24.61 ± 7.85 14.47 ± 4.98 **t=8.36*****	20.03 ± 6.26 15.05 ± 5.74 **t=4.56****	102.06 ± 32.21 75.06 ± 27.71 **t=4.92****

*p<0.05; ** p<0.01; ***p<0.001

Here are HRV data before CABGS of patients with and without ACN were compared. Initial HRV indices had authentic and considerable differences between groups (Table 2). In table 2 you can see, that in patients with ACN (56 pts) the HRV indices were with high authentic less, than in remaining 67 other patients, except of the spectral share of the humoral-metabolic influence in SN and time of achievement maximal reactions in tests and time restorative after stimuli.

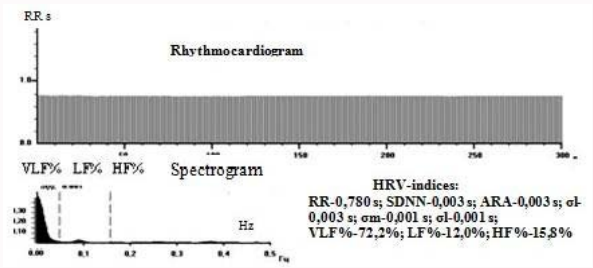

Figure 5: Rcg, the spectrogram and middle of HRV indices during an intubation nacrosis.

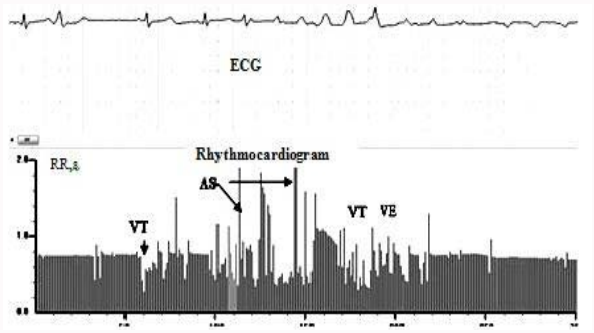

Figure 6: Rcg and the ECG at the clip installation in the aorta.

manipulations on the heart tissues, and it's were removed before analysis of the stationary Rcg-part of. Episodes of the cardiac arrest under influence of introduction of drugs and a Cardio Plegic Solution (CPS) were registered too during preparation of the passage the ABC, till to the restoration of the heart systoles after the shunting. During CABGS the real work was provided to the analysis of results of HRV monitoring and dynamics of its changes. The special program "Stat" was used in statistical evaluation of the computer material for verification of the hypothesis equality of variable rows on criterion Student (t, analogous t -z and p. Normalcy of the distribution was checked on the N. Colmogorov factor with approximation on Yu. Tyurin. For correlative analysis was used nonparametric Spirmen method with program SPSS 12.0.

Results and Interpretation

Initially at primary RCG-research before CABGS HRV reduction was defined, adequate to the CAD expression [1,2,13] at the all patients, selected for the cardiosurgical myocardial revascularization. Except there were before CABGS HRV fragments with HRV stabilization without any wave structure on the Rcg during a paroxysm of the angina pectoris. More exact computer measurements of RR intervals demonstrated on the named fragments the differences between the neighbouring RR intervals within 3.55 ± 1.02 ms (Figure 2). These data were obtained at measurement of each RR interval of thousand stabilization fragments by means of the graphic cursor and the special program. These stabilization fragments correlated to duration of clinical and ECG symptoms of ischemic episodes. It's were the evidence of stenocardia in patients and could be analyzed on the frequency, duration of ischemia, the hemodynamic importance, the functional class of stenocardia initially before operation,

arrhythmogenic background of the autonomic sinoatrial node deregulation (Patent No. 2322942).

Premedication

Before CABGS in 30 minutes a diazepam (seducsen, relium), atropine, promedol were introduced in patients. At the majority of operating patients in response to these drugs there was increase of the humoral-metabolic influence in SN and reduction of sympathetic and parasympathetic indices in HRV regulation (Table 1). In the spectral shares there were the humoral influences in the form of increase of spectral density of the very low-frequency diapason of the HRV in total spectrum (Figure 3). The HRV registration before direct made out of CABGS and cardiac arrest is expedient for the purpose of identification of complications risk during CABGS and registration of the predictors of the intraoperative cardioarrhythmias, because their development was connected with an initial arrhythmogenic background [14]. This background were: dysfunctions of sinoatrial heart node, extremely expressed decrease of all HRV waves (SDNN), because of loss autonomic sympathetic and parasympathetic control in the form of the autonomic cardioneuropathy (ACN) (Figure 2,4,5,8-10,12). There were before CABGS initial episodes of the ischemic autonomic denervation, ECG changes in the form of sinoatrial blockade of 1 or 2 degrees. Before CABGS ACN was defined, as the most significant preoperative marker of life-threatening cardioarrhythmias during CABGS. At selection of patients before CABGS initially there were HRV stabilization and lack of reactions in the stimulant tests. HRV data before CABGS of patients with and without ACN were compared. Initial HRV indices had authentic and considerable differences between groups (Table 2). In table 2 it may be seen, that in patients with ACN (56 pts) the HRV indices were with high authentic less, than in remaining 67 other patients, except of the spectral share of the humoral-metabolic influence in SN and time of achievement maximal reactions in tests and time restorative after stimuli. HRV stabilization at the preoperative period in 100% of cases proceeded to development of cardioarrhythmias during CABGS (Figure 3,6-8). In the patients with ACN its testified about loss of the autonomic control of the SN activity (Table 2). One patient from 123 died through 4 days after CABGS. RCG examination before death showed typical ACN (stabilization of rhythm on the background tachycardia, absent reactions on any stimuli, breaches of the atrial conductivity) before, during and after CABGS. On this background there were episodes of atrial fibrillation, migration of the rhythm pacemaker, the SN dysfunction.

From initially low level of the Rcg during an anesthesia the amplitude of HRV waves decreased even less. At first HRV waves of the fast and sufficient autonomic parasympathetic regulation

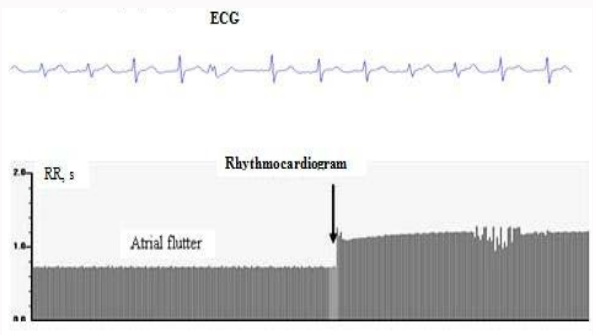

Figure 7: Rcg and ECG at the cannulation of vessels.

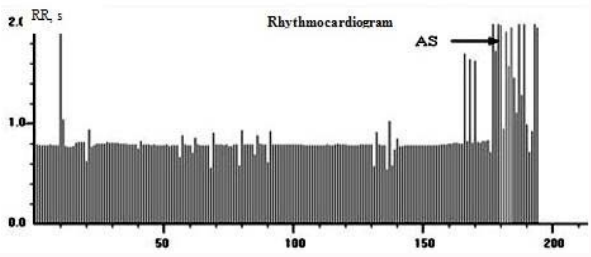

Figure 8: Rcg after introduction of cardioplegic solution.

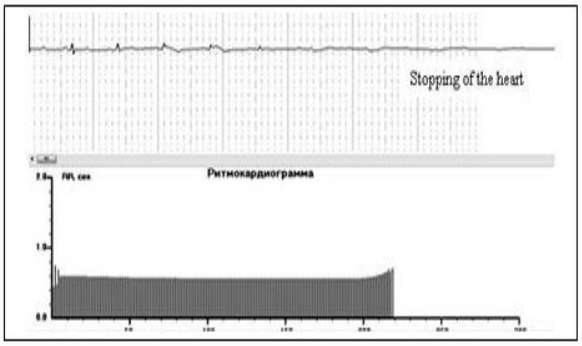

Figure 9: Rcg and ECG during the sinoatrial arrest and connection to apparatus of artificial circulation.

disappeared, then sympathetic, and in the last humoral-metabolic fluctuations. Atrial and ventricular extrasystoles proceeded to total disappearance of HRV waves (n-56, p<0,001). In these cases the HRV regulation transferred up to humoral-metabolic low-amplitude level, which is uneffective and not adequate. In the spectral analysis this correlated to VLF%, which was 72.2-91.2% on the background extremely low share of the autonomic influence in SN (LF% and HF%=2.4% - 15%). The HRV indices of the sympathetic and parasympathetic periodicity-σm, σs- were expressed in units of ms -0,001-0,006 sec., therefore the HRV record, keeping in operative memory and analysis it must be registered with the high exactness, it is necessary. Then the rhythm was completely stabilized, that corresponded to a full anesthesia. In 38 (78,1%) cases were episodes of the rapid rhythm, there were registered signs of breaches of conductivity between atrials because of blockade of the Bachmann bunch, migration of the rhythm pacemaker on SN and atrials, (there were reduction of P wave and change of its form), this corresponded to the high Makruz index.

One of key role in the development of the cardioarrhythmias was the ischemic dysfunction of the myocardium at the surgical myocardial revascularization in the patients operated by CABGS. Frequency of the cardioarrhythmias in these patients significantly negatively with average degree correlated to the background of the myocardial contraction ability reduction (r=0.584-0.638). At the subsequent continuous registration of Rcg the stages of preparation and carrying out of narcosis were registered (Figure 4 and 5). By results of Rcg-record only in 17 (13.8%) patients, which had before CABGS rather safe HRV wave structure, there were registered the supra ventricular extrasystoles and paroxysms of the tachycardia (Figure 6). The supra ventricular extrasystoles were characterized by an uncompensated post ectopic interval on the Rcg and changes of an atrial P wave on the synchronous ECG. This was recognizable visually at the RCG analysis, though possibility of more exact definition pre-

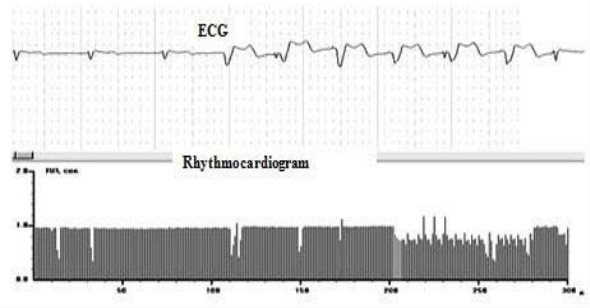

Figure 10: Rcg and ECG.

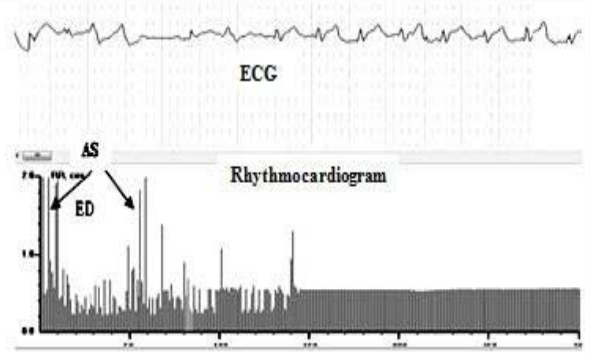

Figure 11: Rcg and ECG during removal of the clip from aorta.

and post ectopic intervals in milliseconds always was preferable. In the others 106 (76.2%) cases the idioventricular rhythm was consistently in the form of migration of the rhythm pacemaker on SN and atrials, with ECG signs of the sinoatrial blockade and changes of the sizes and forms of the P wave, R alternation, usually against extremely expressed HRV decrease in 56 (46.5%) patients with initial ACN, which was registered on Rcg before CABGS. After the premedication and the intubation narcosis the Rcg continuous registration was carried out on the hardware-software complex CAP-RC-02 -"Micor", specially was created for monitor intraoperative record. These records were carried out at stages of the intubation narcosis, the cannulation (Figure 7), installation the clips on vessels (Figure 6), introduction of cardioplegic solution (CPS) (Figure 8), connection up to apparatus of ABC (Figure 9 and 10), restoration of the heart activity after CABGS end (Figure 12).

Cannulation

The cannulation of hollow veins and an aorta was carried out for connection with the apparatus of the ABC (Figure 7**).** Primary volume of filling made 1.5-2l. The structure perfusion solution besides protein, glucose, salt solutions included potassium for stopping of the heart. Transference of the perfusion solution to the blood flow was carried out under control of the Central Venous Pressure (CVP), the blood pressure (BP), and ECG for the purpose of prevention strain in the heart cavities and development of cardioarrhythmias. The beginning of the artificial circulation was accompanied by fast decrease in BP, CVP with prevalence of deposition of the venous blood over receipts it in aorta, decrease in a hemodilution by the blood stream without pulse. At first it was introduction of the 10 mg/kg thyopental, then fentanyl, and at the beginning of the warming - arduan 0.1 mg/kg. For decrease in blood loss was used an ultra filtration. In 97 (80.5%) operated patients there was registered the idioventricular rhythm, it was more often at those patients, which had considerable HRV reduction in the preoperative period, bradycardia and/or delay of the conductivity function (Figure 7). During carrying out CABGS episodes of the accelerated idioventricular rhythm were registered during introduction of a Cardio Plegic Solution (CPS) at the heart arrest.

Cardioplegic solution (CPS) introduction

Anesthesia during of artificial circulation was supported by the barbiturates, neuroleptanalgesia, indepolarizating myorelaxants. The normotermic cardioplegy was applied for myocardial protection against ischemic damage. After achievement of the necessary temperature the clip in aorta was installed, and heart activity stopped. After the cannulation of the veins and aorta, introduction of CPS and hypothermia, there was fibrillation of ventricles was registered and heart stopped (Figure 8 and 9). At the initial HRV low level during the narcosis the amplitude of HRV waves decreased even more. At first HRV waves of the fast autonomic regulation disappeared – protective parasympathetic fluctuations (s), then sympathetic (m), and in the last the humoral-metabolic waves (l). Atrial fibrillation and ventricular extrasystoly preceded to the total disappearance of the HRV (n-48, p<0,001). HRV regulation transferred over on humoral-metabolic level with low HRV waves (VLF%=67.1% - 8.4% in the spectral analysis), then the heart rhythm was completely stabilized, that corresponded to the full narcosis (Figure 4). In 38 (30.9%) cases the tachycardia appeared, because of Bachmann bunch blockade and there were registered signs of breaches conductivity between atrials, migration of the rhythm pacemaker on auricles and nodal complexes, an atrial asystole in the form of reduction P waves, its lengthening and diphasic P wave, increase of an Makruz index. At cardioplegic solution introduction on the background of HRV oppression there was decreased spreading of excitement in the heart ventricles, and amplitude of R waves decreased on the ECG, but still some time R remained in gradual decrease, manifesting the any minimal heart activity [15]. The hemodynamic significant atrial flutter (Figure 7) - AF during CABGS was in the patients with the initial pathological P wave and PQ interval (r = -0.397-0.456) and the other cardioarrhythmias. The more positive result of CABGS was in patients without AF and initial other arrhythmias - in 17 (25.3%) patients. The postoperative restoration in these patients was without complications and it occurred in 1.6 times quicker.

Connection to the apparatus of the artificial blood circulation (ABC)

AF (Figure 6) during CABGS, as variant of atrial tachycardia, appeared much more often than other breaches of the heart rhythm - in 106 (86.1%) of the patients (Figure 9 and 10). Life-threatening AF obligatory was registered at cannulation of the atrials and veins, preparation and carrying out the cardioplegia, before connection to the ABC. At the subsequent cardiac manipulations the AF was registered obligatory in patients with initial ACN – 56 (46.5%) with the HRV stabilization and absent reactions in tests (Table 2 and 3) before CABGS. According to the spectral analysis in the named patients the humoral-metabolic influence on pacemaker cells of SN was considerable prevailing (Figure 3 and 4). These patients had 3 and 4 FC of stenocardia and were most clinically heavy group that confirmed ACN syndrome, as the predictor of AF and the cardioarrhythmias during CABGS (Figure 6,7,10 and 11). The pathogenesis of these breaches was explained by loss of the autonomic control, surgical manipulations, corresponding to their localization, and also dystrophic changes in the SN pacemaker cells. Last was proved in researches with electron microscopy of the autopsy materials of SN

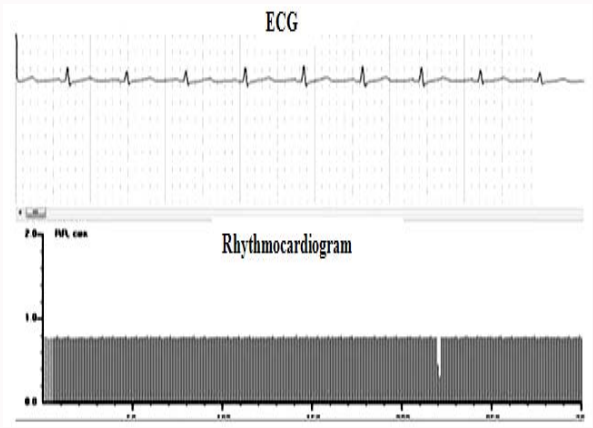

Figure 12: Rcg and ECG during ECG restoration.

Table 3: Analysis of SDNN in patients with atrial flutter (n-86) and without it during CABS.

Average SDNN ± m in seconds		Meaning	meaning
Patients with atrial flutter n=86 (69.9%)	Patients without atrial flutter n=37(30.08%)	Z- criterion	p
0.01229 ± 0.00145	0.01644 ± 0.00228	1.9	p<0.05

in deceased patients [1]. During of CABGS intraoperative record of Rcg (15-18 thousand intervals in each of 123 patients) was carried out, that allowed to register of all changes of the HRV. At the during of the connection to the ABC and gradual cardiac arrest (Figure 6 and 8) the surgical manipulations on the heart auricles and ventricles tissues were accorded by the atrial and ventricular breaches of rhythm in forms of decrease of Rcg level, single and group cardioarrhythmias in 89 (72.2%) patients (Figure 6-11). There were wide ventricular complexes without P waves on the background of normal rhythm, or on the accelerated rhythms (more 100/min.), but it was obligatory in the all patients with ACN. In each case there were the synchronous communication of the rhythm breaches with localization of surgical manipulations was obvious. For example, at the cannulation of aorta and veins the ventricular arrhythmias were registered during manipulations with heart ventricles, atrial arrhythmias were at the aorta clipping in 106 (86.1%) patients at the installation and/or removal of the vessel clips (Figure 6 and 11). Ventricular tachycardia (Figure 8), fibrillation of ventricles appeared before cardiac arrest just before CPS introduction with potassium, transfer of perfusion to apparatus ABC and carrying out CABGS. Direct procedure of the shunting was carried out within 4-10 min and could proceed on the background of the ventricular tachycardia or fibrillation.

The pathological auricles may be manifested by the ECG changes of the P waves at the initial investigation of patients before CABGS, expressive electric alternation, an orientation of the diphasic P waves, changes of duration of PQ, and also height of R. At these cases there were the breaches of the heart rhythm, as a rule, in patients with the background of expressed HRV decrease or its stabilization and the absence of reactions in tests or with slow achievement of the minimal reactions and slow restoration after stimuli in tests in the preoperative period. That corresponded to RCG characteristic to CAD symptoms (Table 2) and before cardiac arrest and passage to ABC. That is, the expressed decrease or stabilization of the HRV and absence of the reactions in tests before CABGS are predictors of the rhythm breaches during operation, including life-threatening cardioarrhythmias. The entire periods – introduction in an anesthesia, the cannulation of the vessels, the hypothermia, CPS introduction with potassium had characteristic in the most cases with visually recognizable form of changes on Rcg. These periods had mathematical Rcg-indices' (Table 4) But the constant HRV –indices manifested the loss of the autonomic control (LF%, HF %) and predominant of the humoral-metabolic influence (VLF %), slow and inadequate in all stages at narcosis.

Before heart arrest, and also at the beginning of the independent heart contractility there was a true atrial flutter (AF) 1:2, 1:3, 1:4 on the macro re-entry pathogenesis round the right atrioventricular valve on the background anesthesia in 86 (69.9%) patients (Figure 7). The differential diagnostics between AF and intsizion tachycardia assumes from these two variants of arrhythmia after all AF. To istmus-dependence of AF, as to the main difference from intsizion tachycardia, in the discussed cases may be add ECG changes, which initially connected with auricles, and also connected to AF with localization of surgical manipulations in the named atrials. Declared prevalence of sympathetic influences at the forming AF, as the autonomic pathogenesis link of AF, apparently needs in the evidences. Here are the same contrarguments - the insufficient accuracy of registration and the HRV analysis, and also ignoring of a humoral influence on the SN regulation, when forming potentials in the pacemaker cells of the SN. In the Table 3 there is shown the connection of AF with low HRV. The meaning of SDNN in patients without atrial flutter was reliability more, than in patients with this arrhythmia. This is testimony of pathogenic influence of the HRV reduction at the appearance of these cardioarrhythmias during CABGS and surgeon manipulations.

If there was no independent restoration of the heart activity after removal of the clips from aorta and on the monitor Rcg and ECG the fibrillation of ventricles or the migration of rhythm pacemaker were registered, in this case the electric defibrillation (ED) of heart was carried out (Figure 11). In 15 cases at the development of asystolia direct massage of the heart was carried out. In compliance with HRV indices the extremely lowered autonomic regulation in SN remained during all CABGS. The lowest indices belonged to parasympathetic fluctuations - in all stages CABGS their amplitude consists only 1-2 ms on the background permanent prevailing influence in SN of the humoral-metabolic factor, slow, insufficient, sometimes causing paradoxical reaction. The cardioarrhythmias registered mainly during the stages, being accompanied by surgical manipulations on the heart tissues in patients with extremely low HRV.

Conclusion

1. The high-resolution rhythmocardiography with HRV analysis are the adequate and perspective method of evaluation of the actual cardiovascular status before and during carrying-out of the cardiosurgical myocardial revascularization in patients with angina pectoris.

2. The HRV analyzed in time- and frequency-domains consists the supplementary symptoms for the intranosological diagnostics at the selection of patients for the cardiosurgical treatment of the stenocardia, and mainly it consists HRV symptoms of the high risk of complications during CABGS, including the cardioarrhythmias.

3. The results of HRV researches testimonies about the possibilities of definition of the high risk of life-dangerous arrhythmias and also lethal outcome at the CABGS. The loss of

Table 4: The average HRV indices during stages of the coronary artery bypass graft surgery (CABGS) (n-123).

Average HRV indices (M ± σ) in seconds(s) and %. Cardioarrhythmias	**RR** s Average RR interval	**SDNN** s, average quadratic deviation of all HRV waves	**σl,** s average quadratic deviation of humoral HRV waves	**σm**,s average quadratic deviation of sympathetic HRV waves	**σs**, s average quadratic deviation of parasympathetic	**VLF%** spectral share of humoral HRV waves	**LF%** spectral share of sympathetic HRV waves	**HF%** spectral share of parasympathetic HRV waves
Intubation and narcosis	0.783 ± 0.03	0.003 ± 0.001	0.003 ± 0.001	0.001 ± 0.001	0.001 ± 0.001	72.2 ± 18.4%	12.8 ± 4.23%	15.0 ± 3.5%
Cannulation. AF, ventr. arrhythmias	0.653 ± .024	0.003 ± 0.001	0.003 ± 0.001	0.001 ± 0.001	0.001 ± 0.001	84.2 ± 11.2%	7.4 ± 3.4%	8.4 ± 2.82%
Introduction of CPS, AF, ventr. arrhyt-mias, asystolia	0.810 ± 0.033	0.004 ± 0.001	0.002 ± 0.002	0.004 ± 0.001	0.001 ± 0.001	91.2 ± 7.2%	6.4 ± 2.33%	2.4 ± 1.87%
Connection to artificial circulation	0.580 ± 0.087	0.002 ± 0.001	0.002 ± 0.002	0.002 ± 0.001	0.001 ± 0.001	90.2 ± 10.8%	6.8 ± 3.2%	3.0 ± 1.9%
Removal clips, heart restoration. Heart arrhytmias	0.564 ± 0.034	0.003 ± 0.001	0.003 ± 0.001	0.002 ± 0.001	0.001 ± 0.001	88.6 ± 12.4%	5.4 ± 1.9%	5.0 ± 2.1%
Heart restoration	0.680 ± 0.110	0.006 ± 0.002	0.006 ± 0.002	0.002 ± 0.001	0.001 ± 0.001	87.2 ± 7.12%	5.0 ± 2.1%	7.8 ± 3.4%

Here are data of statistic and spectral analyses of HRV indices at the different stages of CABS. After intubation narcosis HRV indices are very low. Initially low HRV indicators before operation during narcosis became also low and amount to units of milliseconds. The most high amplitude belonged to the humoral-metabolic HRV waves (σl), although low too. At the spectral correlation of the shares of the regulative factors in SN the humoral-metabolic environment influence in SN (VLF%) was predominant over autonomic sympathetic (LF%) and parasympathetic (HF%) influences during all stages of CABGS.

peripheral autonomic control in the sinoatrial node, as syndrome of the autonomic cardioneuropathy, is the predictor of complications at the cardiosurgical operation.

4. The receiving data about multitude variants of deregulations of the sinus heart node pacemaker activity corresponded to stages of the cardiosurgical operation, connecting with ischemic breaches of the coronary arteries, as soon as with localization of the cardiosurgical manipulations during CABGS.

5. There was proved, that coronary artery disease obligatory accompanied by the deregulations of the pacemaker activity of the sinus heart node. Its dynamics corresponded to actual cardiovascular status of patients and may be used at their cardiosurgical treatment.

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