Galician Medical Journal

Scientific and Practical Journal of Ivano-Frankivsk National Medical University

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Electrolyte Imbalance in Cardiology Practice

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Abstract. **The objective** of the research was to establish the dynamics of electrolyte balance, pyruvate and lactate in patients with arterial hypertension (AH), long QT syndrome and heart rate turbulence.

Materials and methods. The study included 60 patients with stage II AH. All patients were divided into three groups: Group I included 20 patients with stage II AH and normal myocardial electrical stability; Group II included 20 patients with stage II AH and long QT syndrome (LQTS); Group III comprised 20 patients with stage II AH and heart rate turbulence (HRT). The control group included 20 practically healthy persons. The parameters of heart rate turbulence, QT-interval duration, potassium, magnesium, calcium, lactate and pyruvate levels were determined.

Results. A total calcium level in patients of Groups II and III increased by 27.14% ($p<0.001$) and 29.41% ($p<0.001$) compared to Group I, and ionized calcium level increased by 27.14% ($p<0.001$) and 27.65% ($p<0.001$), respectively. The level of potassium in Groups II and III was 20.63% ($p<0.001$) and 19.59% ($p<0.001$) lower than in Group I, and magnesium level was 14.51% ($p<0.001$) and 12.69% ($p<0.001$) lower compared to Group I. The level of pyruvate in Group II decreased by 60.53% ($p<0.001$), and in Group III it decreased by 54.84% ($p<0.001$). The level of lactate increased by 27.01% ($p<0.001$) and 25.24% ($p<0.001$), respectively.

Conclusions. Considering the obtained results, deeper investigation of the role of electrolyte balance in the pathogenesis of arterial hypertension and myocardial electrical instability should be continued.

Keywords: arterial hypertension; magnesium; potassium; calcium; myocardial electrical instability

Problem statement and analysis of the recent research

Cardiovascular disease remains the leading cause of death worldwide. Arterial hypertension (AH) is the main risk factor for cardiovascular diseases and their complications. In Ukraine there are about 12 million people with AH [2]. One of the urgent problems of modern cardiology is prediction of electrical instability of the myocardium being a key mechanism of sudden death and the development of malignant cardiac arrhythmias [1, 3, 4]. In the course of myocardial electrical instability electrolyte imbalance of the whole organism as well as changes in limited areas of the myocardium leading to changes in the extracellular and intracellular electrolyte concentrations are of great importance [3, 4, 5]. The fundamental mechanism of physiological effects of magnesium is its function as a natural calcium channel blocker. This mechanism obviously determines antianginal, antiarrhythmic and antihypertensive properties of magnesium [5]. Magnesium ions are of particular importance in maintaining the transmembrane potential. Therefore, magnesium plays a special role in functioning of tissues having the ability to conduct excitation waves and spontaneous electrical activity [3, 5]. Magnesium also prevents loss of potassium in the cell and reduces the QTinterval duration, which is prognostically unfavorable factor of arrhythmia [3, 4].

The objective of the research was to establish the dynamics of electrolyte balance, pyruvate and lactate in patients with arterial hypertension (AH), long QT syndrome and heart rate turbulence.

Materials and methods

The study included 60 patients with stage II AH. All patients were divided into three groups. Group I included 20 patients with stage II AH and normal myocardial electrical stability. Group II included 20 patients with stage II AH

and long QT syndrome (LQTS). Group III comprised 20 patients with stage II AH and heart rate turbulence (HRT). The control group included 20 practically healthy persons. The average age was 56.35±1.36 years.

Verification of the diagnosis, determination of the stage and degree of hypertension were conducted according to the criteria recommended in 2013 by the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC). Diagnostics of LQTS syndrome was performed using criteria suggested by P. Schwartz (1985), and diagnostics of HRT was performed according to G. Schmidt, et al. (1999). HRT was established on the basis of Holter-ECG monitoring using indicators of heart rate turbulence "onset" (HRTO, %; norm<0%) and "slope" of the regression line - heart rate turbulence "slope" (HRTS, ms/RR interval; norm>2.5 ms/RR).

The indicators of HRTO (%), (Fig. 2.1) and HRTS (ms/RR), (Fig. 2.2) were determined as follows: HRTO (%)=((C+D)-(A+B)/(A+B))×100%, where A and B were two RR intervals (ms) before the ventricular extrasystole, C and D were two RR intervals (ms) after the post-extrasystolic pause (Fig. 2.1).

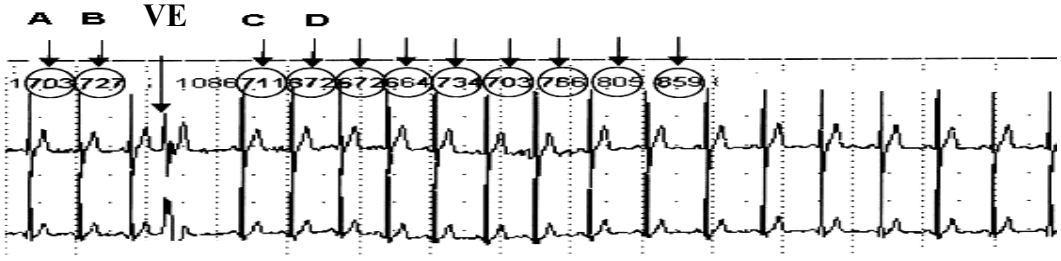

Fig. 2.1. Method of measuring RR intervals before and after the ventricular extrasystoles

HRTS (ms/RR) was determined by the slope of the regression line for each 5 RR intervals after the post-extrasystolic pause (Fig. 2.2).

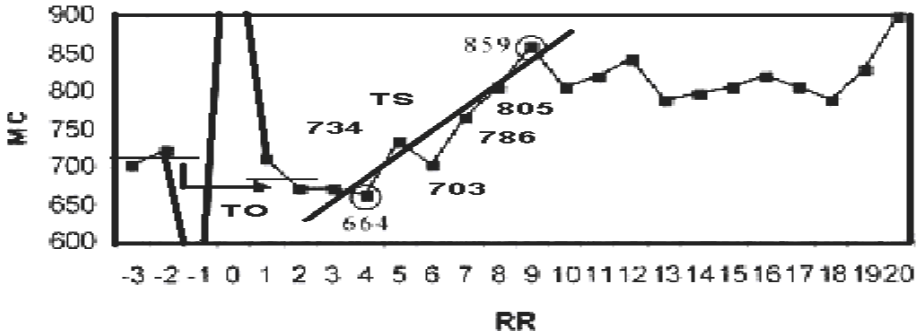

Fig. 2.2. Method of calculation of HRTS (ms/RR)

Functional studies were performed in Ivano-Frankivsk Regional Clinical Cardiology Dispensary. Magnesium, potassium, calcium, pyruvate and lactate levels were determined in the laboratory at the Department of Biochemistry of Ivano-Frankivsk National Medical University. The obtained data were statistically processed using the computer program STATISTIKA-8 and statistical software package "Microsoft Excel". We determined the arithmetic mean M, standard error of the mean M, the number of variant (n), the probability of the difference between two arithmetic means "p". Correlation analysis was performed using the Pearson's correlation coefficient (Rxy).

Results

The data in Table 1 indicated disorders of electrolyte metabolism in patients. A total calcium level in patients of Groups II and III increased by 27.14% ($p<0.001$) and 29.41% ($p<0.001$) compared to Group I, and ionized calcium level increased by 27.14% ($p<0.001$) and 27.65% ($p<0.001$), respectively. The level of potassium in Groups II and III reduced by 20.63% ($p<0.001$) and 19.59% ($p<0.001$), respectively. The level of magnesium was 14.51% ($p<0.001$) and 12.69% ($p<0.001$) lower compared to Group I. QT prolongation involves prolongation of ventricular repolarization with low concentration of magnesium ions increasing the risk for ventricular arrhythmias. In patients of Groups II and III acidosis caused by low pyruvate and high lactate levels was observed. The level of pyruvate in Group II was 60.53% ($p<0.001$)

lower than in Group I, and in Group III it decreased by 54.84% (p<0.001) compared to Group I. The level of lactate increased by 27.01% (p<0.001) and 25.24% (p<0.001), respectively compared to Group I.

Table 1

Indicators of electrolyte balance in patients, M ± m

Index	Control group n=20	Main group		
		Group I n =20	Group II n =12	Group III n=10
Ca^{2+} (total), mmol/l	2.46±0.05	2.04±0.08*	2.8±0.03*##	2.89±0.03*##
Ca^{2+} (ionized) mmol /l	1.23±0.06	1.02±0.05*	1.4±0.06*##	1.41±0.05*##
K^{+}, mmol /l	4.25±0.09	4.15±0.08**	3.44±0.11* ##	3.47±0.1*##
Mg^{2+}, mmol/l	0.77±0.03	0.71±0.02**	0.62±0.02*#	0.63±0.02*##
Pyruvate, mcmol/l	63.0±2.92	65.5±2.56	40.8±3.14*##	42.3±2.9*##
Lactate, mcmol/l	1.48±0.05	1.54±0.04	2.11±0.1*##	2.06±0.1*##

Notes:

1. the significance of data difference compared to values of healthy people (* – p<0.001; ** – p<0.05);
2. the significance of data difference compared to patients with normal electrical stability (# – p<0.05; ## – p<0.001).

There was found a medium-strength correlation between the calcium content (r=-0.36, p<0.05), the QT interval duration (r=-0.38, p<0.05) and the level of pyruvate; between the levels of ionized calcium and lactate (r=- 0.43, p<0.05); between the QT interval duration and the level of potassium (r=-0.53, p<0.05) indicating the increase in the level of calcium in acidosis. There was detected a medium-strength direct correlation between the level of magnesium and HRTS (r=0.66, p<0.05); the level of ionized calcium and the QT interval duration (r=0.31, p<0.05).

Discussion

Changes in the electrolytic status can be accompanied by heart rhythm disorders with further occurrence of ventricular extrasystoles, changes in the parameters of HRT, duration and dispersion of QT interval.

Conclusions

1. Disturbed ion channel function results in prolonged electrical systole and QT interval.
2. The levels of magnesium, potassium and calcium, as well as the QT interval duration and parameters of HRT can be used as prognostic tests for assessing electrical instability of the myocardium.
3. There was proved a direct correlation between the level of magnesium and HRTS; between the level of pyruvate, ionized calcium, potassium and the QT interval duration.
4. Considering the obtained results, deeper investigation of the role of electrolyte balance in the pathogenesis of AH and myocardial electrical instability should be continued.

Prospects for further research

Further scientific research is recommended to direct at studying the dynamics of electrolyte balance when treating patients with hypertension and co-existent myocardial electrical instability.

References

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