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The influence of polarizing GIK mixture treatment on electrolyte equilibrium, serum osmolality and the size of osmotic gap in patients with acute myocardial infarction

In the course of myocardial infarction a number of systemic humoral reactions appear such as the increase in the activity of the sympathetic - adrenal system and renin-angiotensin-aldosterone system, insulin secretion disorders and increase in cortisol secretion, which condition the appearance of many electrolyte and metabolic disturbances (2, 3, 9, 11, 12). For many years attempts have been made to treat acute myocardial infarction by various methods restricting the area of necrosis and correcting the existing metabolic disorders. For this purpose, with acute myocardial infarction a GIK mixture is administered, containing glucose, insulin and potassium (5, 6). One of parameters which may be useful to evaluate a patient's general condition is the measurement of serum osmolality and osmotic gap. They can be subject to change in the course of myocardial infarction due to disorders in peripheral circulation and ischaemia of many tissues and organs.

MATERIAL AND METHODS

The study was carried out in 44 patients: 19 with anterior myocardial infarct and 25 with inferior infarct. The average age of patients was 62. The group consisted of 32 men and 12 women.

The studied patients were divided into two groups: the first group included patients who apart from typical treatment in myocardial infarction were given during the first 24 h the infusion of polarizing GIK mixture (1000 ml of 5% glucose, 10 units of maxirapid insulin and 6.0 g of KCl); the second group (placebo) consisted of patients who apart from typical treatment in myocardial infarction were given during the first 24 h the infusion of 1000 ml of 0.9 % NaCl. Each patient included in the study, directly before the treatment and after 24 hours' GIK or placebo treatment, had the following parameters checked: concentration of sodium and potassium electrolytes, osmolality by the direct method, osmolality calculated from the formula, and osmotic gap. The concentration of electrolytes in the serum was determined by flame photometry using the Corning 480 lab equipment. Total osmolality was measured by the cryoscopic method using Trident osmometer. Calculated osmolality was determined using the formula.

$$\text{OSMOLALITY} = 2x\,(Na+) + (\text{UREA}/3) + (\text{GLUCOSE}/20) \quad (1)$$

Osmotic gap was calculated by subtracting the value of calculated osmolality from the value of total osmolality. The obtained results were statistically analyzed using the Statistica for Windows 5.0 programme, t-Student test and χ 2 test. Statistical significance was assumed for $p < 0.05$.

RESULTS

The results of potassium and sodium concentrations, osmolality and osmotic gap were shown in Tables 1, 2, 3, 4 and 5. The average potassium concentration in patients with myocardial infarction before the treatment was 4.1 mEq/l. In the group of patients treated with GIK the average potassium concentration on initial examination was 4.2 mEq/l and in the placebo group – 3.9 mEq/l. After 24 h of treatment the potassium level showed a statistically significant rise in all the patients and was 4.3 mEq/l. In the GIK group it rose to 4.4 mE/l and in the placebo group to 4.2 mEq/l. The increase was statistically significant in all the groups (p=0.02).

Table 1. Potassium concentration in blood serum during GIK and placebo treatment in patients with myocardial infarction

				KIG anterior wall infarction	
				exam 1	exam 2
				4.4±0.5	4.5±0.4
				NS	
		KIG		KIG inferior wall infarction	
		exam 1	exam 2	exam 1	exam 2
Whole group		4.2±0.4	4.4±0.4*	4.1±0.3	4.4±0.4
exam 1	exam 2	p=0.039		p=0.022	
4.1±0.4	4.3±0.4	placebo		placebo anterior wall infarction	
p=0.006		exam 1	exam 2	exam 1	exam 2
		3.9±0.4	4.2±0.4*	4.2±0.4	4.3±0.4
		NS		NS	
				placebo inferior wall infarction	
				exam 1	exam 2
				3.8±0.2	4.1±0.4
				p=0.02	

*Statistically significant differences between the groups in the examination after 24 hours

Table 2. Sodium concentration in blood serum during GIK and placebo treatment in patients with myocardial infarction

				KIG anterior wall infarction	
				exam 1	exam 2
				138.1±5.1	139.4±4.2
				NS	
		KIG		KIG inferior wall infarction	
		exam 1	exam 2	exam 1	exam 2
Whole group		139.1±4.8	140.4±3.3	139.9±4.5	141.1±2.3
exam 1	exam 2	NS		P=0.043	
139±4.6	140.2±3.3	placebo		placebo anterior wall infarction	
NS		exam 1	exam 2	exam 1	exam 2
		138.8±4.4	140.1±3.4	138.7±5.3	140.1±3.2
		NS		NS	
				placebo inferior wall infarction	
				exam 1	exam 2
				138.9±4	140±3.7
				NS	

Table 3. Blood serum osmolality during GIK and placebo treatment in patients with myocardial infarction

				KIG anterior wall infarction	
				exam 1	exam 2
				296±14	292±14
				NS	
		KIG		KIG inferior wall infarction	
		exam1	exam 2	exam 1	exam 2
Whole group		299±10	298±11	300±7	301±7
exam 1	exam 2	NS		NS	
301±11	298±13	placebo		placebo anterior wall infaction	
NS		exam 1	exam 2	exam 1	exam 2
		304±11	299±15	304±10	300±9
		NS		NS	
				placebo inferior wall infarction	
				exam 1	exam 2
				304±13	297±18
				NS	

Table 4. Calculated blood serum osmolality during GIK and placebo treatment in patients with myocardial infarction

				KIG anterior wall infarction	
				exam 1	exam 2
				291±9	288±13
				NS	
		KIG		KIG inferior wall infarction	
		exam 1	exam 2	exam 1	exam 2
Whole group		289±10*	289±12	289±11	290±11
exam 1	exam 2	NS		NS	
293±10	292 ±12	placebo		placebo anterior wall infarction	
NS		exam 1	exam 2	exam 1	exam 2
		297±7*	295±11	298±5	294±11
		NS		NS	
				placebo inferior wall infarction	
				exam 1	exam 2
				297±8	296±11

*Statistically significant differences between the groups in initial examination

The average sodium concentration on initial examination in all the patients was 139 mEq/l: in the GIK group 139.1 mEq/l and in the placebo group 139.8 mEq/l; the differences between the groups were statistically insignificant. After 24 h of treatment the increase in sodium concentration was not statistically significant in both groups: in the GIK group it rose to 140.4 mEq/l and in the placebo group to 140 mEq/l.

Measured osmolality in all the patients was 301 mOsmol/kg H_2O: in the GIK group it was 299 mOsmol/kg H_2O, in the placebo group 304 mOsmol/kg H_2O. After 24 h of treatment blood serum osmolality decreased in all the patients to 298 mOsmol/kg H_20: in the GIK group to 298 mOsmol/kg H_2O and in the placebo group to 299 mOsmol/kg H_2O. The decrease in plasma osmolality was not statistically significant.

Calculated osmolality on initial examination in all the patients was 293 mOsmol/kg H_20 and after 24 h it decreased to 292 mOsmol/kg H_2O. In the GIK group and in the placebo group it was 289 mOsmol/kg H_2O and 297 mOsmol/kg H_2O, respectively. After 24 h of treatment osmolality in the GIK group was kept at a steady level and in the placebo group it decreased to 295 mOsmol/kg H_2O (statistically insignificant).

Osmotic gap on initial examination in all the patients was 8.7 mOsmol/kg H_2O on the average; after 24 h it decreased to 7.7 mOsmol/kg, the H_2O difference was not statistically significant. Taking into account the two groups separately, GIK group and placebo group, osmotic gap on initial examination in GIK group was 10 mOsmol/kg H_2O and after 24 h it decreased to 9.6 mOsmol/kg H_2O; in placebo group osmotic gap decreased from 6.9 mOsmol/kg on initial examination to 5.0 mOsmol/kg H_2 after 24 h. The differences were not statistically significant.

Table 5. Osmotic gap in blood serum during GIK and placebo treatment in patients with myocardial infarction

<table>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2">KIG anterior wall infarction</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td>exam 1</td><td>exam2</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td>5.1±9.5</td><td>3.9±6.9</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2">NS</td></tr>
<tr><td colspan="2"></td><td colspan="2">KIG</td><td colspan="2">KIG inferior wall infarction</td></tr>
<tr><td colspan="2"></td><td>exam 1</td><td>exam 2</td><td>exam 1</td><td>exam 2</td></tr>
<tr><td colspan="2">Whole group</td><td>10±11</td><td>9.6±10.2</td><td>12.9±11.1</td><td>12.9±10.6</td></tr>
<tr><td>exam 1</td><td>exam 2</td><td colspan="2">NS</td><td colspan="2">NS</td></tr>
<tr><td>8.7±9.7</td><td>7.7±10.5</td><td colspan="2">placebo</td><td colspan="2">placebo anterior wall infarction</td></tr>
<tr><td colspan="2">NS</td><td>exam 1</td><td>exam 2</td><td>exam 1</td><td>exam 2</td></tr>
<tr><td colspan="2"></td><td>6.9±7.5</td><td>5±10.6</td><td>6.6±6.8</td><td>7.5±10.2</td></tr>
<tr><td colspan="2"></td><td colspan="2">NS</td><td colspan="2">NS</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2">placebo inferior wall infarction</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td>exam 1</td><td>exam 2</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td>7±8.3</td><td>3.6±11.1</td></tr>
<tr><td colspan="2"></td><td colspan="2"></td><td colspan="2">NS</td></tr>
</table>

DISCUSSION

Acute myocardial infarction is accompanied by various neurohumoral and metabolic disorders resulting from the stimulation of sympathetic-adrenal system and renin-angiotensin-aldosterone system and haemodynamic disorders which cause ischaemia of many tissues and organs. Consequently, disorders of protein and carbohydrate metabolism appear as well as unfavourable shifts in the acid-base equilibrium and water and electrolyte balance upsetting the osmotic balance of the organism (2, 3, 4, 9).

Hypoxia of tissues and organs causes the appearance in the patients' blood serum of various pathogenic micromolecular and medium-sized molecular substances contributing to the creation of osmotic gap defined as the difference between measured and calculated serum osmolality (10).

The studies allowed to characterize the influence of myocardial infarction and polarizing GIK mixture on the condition of water and electrolyte and osmotic equilibrium of the organism during the first hours of myocardial infarction. It turned out that potassium concentration in the serum at the onset of the disease showed a downward trend although it stayed a little above the lower limit of the norm. It is probably the result of the above mentioned aldosterone excess in spite of the loss of intracellular potassium resources caused by ischaemia and the shift of the ion from intracellular to extracellular space.

Treatment with polarizing mixture causes favourable changes in the electrolyte equilibrium raising the potassium concentration in the serum. Besides, the activity of polarising GIK mixture is to prevent the loss of intracellular potassium and thanks to the content of insulin, glucose and potassium it is to cause a re-shift of potassium to the cell inside. It can be of a considerable importance to the maintenance of myocardial vitality in the period of acute ischaemia.

The studies confirmed the existence in the first hours of infarction of transient hyponatraemia, also observed by other authors, and a gradual increase in the concentration of this electrolyte with time (7, 8).

In the evaluation of patient's condition serum osmolality and osmotic gap are rarely determined parameters (as opposed to other countries). They indicate the appearance in the patients' blood serum of indeterminable microcellular and medium-sized particles, normally being endogenic organ toxins. Their compactness increases in the states of organ hypoxia. Osmotic gap can thus be an indicator of oxygen availability to tissues. The studies revealed a small decrease in the serum osmolality and osmotic gap after the first 24 h of infarction treatment compared with the initial values. However, no considerable influence of polarizing GIK mixture on those two parameters was found. The fact of small changes in osmolality and the size of osmotic gap in the observed patients can be explained by strict principles of admission for studies, which excluded patients in shock, pulmonary oedema, with diabetes, renal failure and poor general condition.

CONCLUSIONS

1. Acute myocardial infarction is accompanied by infavourable shifts in electrolyte equilibrium and osmotic balance of the organism.
2. Administration of polarizing GIK mixture has a favourable influence on the parameters of electrolyte equilibrium of the organism.
3. The study of osmotic gap can be a precious indicator in patients in life-threatening states.

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SUMMARY

In the studies there have been evaluated of the concentration of electrolytes –sodium and potassium,osmolality of blood and the size of osmotic gap in serum of patients with acute myocardial infarction and the influence of polarizing mixture treatment on the value of those parameters that have been examined. The changes of the examined parameters have been statistically analyzed in both groups: patients treated with polarizing KIG and patients who were given placebo. The treatment with polarizing mixture causes favourable changes in the electrolyte equilibrum rasing the concentration of potassium in the serum and preventing the loss of intracellular potassium. No significant influence of treatment with polarizing KIG on serum osmolality and the size of osmotic gap has been observed.

Wpływ leczenia mieszanką polaryzującą KIG na gospodarkę elektrolitową, osmolalność surowicy oraz wielkość luki osmotycznej u chorych ze świeżym zawałem mięśnia serca

W pracy oceniono poziom elektrolitów – sodu i potasu, osmolalność osocza i wielkość luki osmotycznej w surowicy krwi chorych ze świeżym zawałem mięśnia serca oraz zbadano wpływ leczenia mieszanką polaryzującą KIG na wartość tych parametrów. Analizie statystycznej poddano zmiany badanych parametrów w grupie chorych leczonych KIG-iem i w grupie otrzymującej placebo. Leczenie mieszanką polaryzującą KIG powoduje korzystne zmiany w równowadze elektrolitowej, podwyższając stężenie potasu w surowicy krwi i zapobiegając utracie potasu wewnątrzkomórkowego. Nie zaobserwowano istotnego wpływu leczenia mieszanką polaryzującą KIG na osmolalność surowicy i wielkość luki osmotycznej.