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RED BLOOD CELL ELECTROLYTE CHANGES IN PATIENTS WITH JUVENILE DIABETES MELLITUS

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The sodium and potassium concentrations of the red blood cells and the serum were investigated in 21 children with diabetes mellitus. Measurements were made prior to and 1 and 2 hours following insulin administration. Before insulin treatment, the sodium level in the red blood cells of the diabetes patients was significantly higher that the control level, while the potassium level was significantly depressed. These differences were not observed 1 and 2 hours following insulin administration. Attention is drawn to the rapid and extensive electrolyte changes in the red blood cells of diabetics in response to insulin. The potassium content of the serum of the diabetics was significantly decreased by insulin administration. No correlation was found between the electrolyte levels and the fasting blood glucose levels. A weak negative correlation (p 0.02) was observed between the potassium content of the red blood cells and the duration of the illness. The pathogenetic, diagnostic and therapeutic implications of the results are discussed.

INTRODUCTION

The changes in the red blood cells in diabetic patients may, in some respect, reflect pathologic events in other cells, and hence may be of aid in the understanding of certain diabetic cellular processes /7, 16, 17, 18, 22, 24, 27/. We have examined the electrolyte concentration changes in the red blood cells and the plasma before and 2 hours after insulin administration. Further correlations were sought between the ion

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changes in the red blood cells, the blood glucose level, the insulin dose and the duration of the disease.

PATIENTS AND METHODS

Our juvenile diabetic patients (13 girls and 8 boys) were in good general condition, and had no ketoacidosis or febrile catarrhal disease. The duration of their illness varied between 1 and 126 months; the average duration was 43.7 months. The insulin dose varied between 0.33 and 1.37 IU/kg. Actrapid MC or Monotard MC insulin was administered twice a day.

The controls were children of different ages and sexes, not suffering from any metabolic disease; the majority of them were recovering from mild catarrhal infections. The electrolyte contents of the red blood cells were measured as described by Fortes Mayer and Starkey /8/. Insulin was administered at 6.30 a.m., 30 min later the children had breakfast, and blood was taken in 0 min. then after 1 and 2 hours. The controls had breakfast together with the diabetic children, but naturally received no insulin.

For statistical analysis the single- and two-tailed t-tests and calculation of the regression coefficient were used.

RESULTS

Table I depicts the Na^+ concentrations in the plasma and the red blood cells of the controls and diabetic patients. The Na^+ levels in the plasma remained unchanged all the while in both the controls and in diabetic patients. In the controls the Na^+ levels in red blood cells were likewise unchanged. In the red blood cells of the diabetic patients, however, the Na^+ levels were initially significantly elevated, but normalized after insulin administration. Table I demonstrates the K^+levels in the plasma and the red blood cells of the controls and the diabetic patients. The control plasma K^+ levels remained unchanged. In contrast, in the diabetic children the plasma K^+ level was initially normal, but 1 hour after insulin administration it was significantly lower than the control level. This difference could not be observed 2 hours after insulin administration. The K^+ level in the red blood cells of the diabetic patients was initially significantly lower than

TABLE I

	Se Na^+ mmol/l		Two-tailed T-test	SeK^+ mmol/l		Two-tailed T-test	Red blood cell Na^+ mmol/l		Two-tailed T-test	Red blood cell K^+ mmol/l		Two-tailed T-test
	controls	diab. mell.	p	controls	diab. mell.	p	controls	diab. mell.	p	controls	diab. mell.	p
0^h	138,77 ±2.93	138.71 ±3.45	>0.20 n.s.	4.17 ±0.48	4.25 ±0.34	>0.51 n.s.	6.59 ±0.92	7.6 ±1.31	<0.006 sign.	93.29 ±2.73	86.89 ±5.07	<0.006
1^h	138.91 ±3.66	138.0 ±2.85	>0.50 n.s.	4.15 ±0.54	3.676 ±0.35	<0.001 sign.	6.63 ±0.80	6.36 ±1.21	>0.38 n.s.	93.14 ±2.37	94.64 ±6.21	>0.30 n.s.
2^h	138.5 ±3.04	138.38 ±2.73	>0.20 n.s.	4.11 ±0.50	3.97 ±0.44	>0.341 n.s.	6.62 ±0.74	7.14 ±1.22	>0.097 n.s.	93.19 ±2.36	90.31 ±5.10	>0.08 n.s.
single-tailed T-test p_{0-1^h}	>0.37 n.s.	>0.20 n.s.		>0.50 n.s.	<0.001 sign.		>0.30 n.s.	<0.001 sign.		>0.42 n.s.	<0.001 sign.	
p_{0-2^h}	>0.50 n.s.	>0.5 n.s.		>0.20 n.s.	<0.001 sign.		>0.07 n.s.	<0.001 sign.		>0.10 n.s.	<0.02 sign.	
p_{1-2^h}	>0.20 n.s.	>0.20 n.s.		>0.20 n.s.	<0.001 sign.		>0.27 n.s.	<0.001 sign.		>0.27 n.s.	<0.001 sign.	

Changes in the serum and red blood cell electrolyte contents of control, and of diabetic children. Samples were taken from diabetic children before insulin treatmant, and 1 and 2 hours after the meal following insulin administration. Blood samples were taken from the control children before breakfast and 1 and 2 hours after it. (Control: n = 22; diabetes mellitus patients n = 21, mean values ± SD)

the control level. In response to insulin, however, the K^+ levels in the red blood cells of the diabetics increased up to the control levels. We did not find significant correlation between the fasting electrolyte results and the blood glucose level or the insulin dose (UI/kg). The fasting K^+ levels in the red blood cells and the duration of the illness in months showed merely a slight negative correlation ($p < 0.02$).

DISCUSSION

The electrolyte contents of the red blood cells, to a certain extent, reflect those of the other cells of the organism /23, 26, 28/. Accordingly, fluctuations in the electrolyte contents of the red blood cells may be indicative of the unstable intracellular electrolyte turnover of the diabetic organism. From the point of view of the cell function, the Na^+- K^+-pump is important /10/; and this may be influenced by insulin /2, 3, 4, 5, 9, 21/ among others. In diabetes, the disturbance of this system may be assumed, and this may lead to certain changes /6, 15, 19, 20, 21 29/. It may be assumed that complex effects may be responsible for the induction of fluctuations observed in the electrolyte contents of the diabetic red blood cells. The membrane changes in the diabetic red blood cells may play a role in the development of a lower K^+ and higher Na^+ levels observed in diabetic red blood cells before the administration of insulin; while in the recovery of the electrolyte balance the pharmacologic dose of insulin and the glycaemic effect following the meal - among other factors - may also be involved.

Beside the pathogenetic importance of the intracellular electrolytes, they may also be of diagnostic value. Though the correlation between the glucose and electrolyte transport of the cells is not yet clear /1, 2, 3, 4, 5, 11, 12, 13, 14, 21, 25/, it may be presumed that these two phenomena are not

closely related in every sorts of cells. The present experiments also demonstrated that no significant correlation does exist between the electrolyte levels of the red blood cells and the fasting blood glucose levels either. It may be assumed that, in addition to the extracellular glucose, the intracellular electrolyte levels are similarly important diagnostic parameters. Finally, the red blood cells' electrolyte results may have therapeutic consequences. Especially the compensation of K^+ should be taken into consideration. Our experiments suggest a progressive decrease in the K^+ level in the red blood cells of diabetic patients, in spite of the normal plasma K^+ level. Moreover, as assumed by Moore /21/, the intracellular electrolyte levels that reflect the insulin effect should be taken into consideration in the calculation and distribution of the insulin dose.

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