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The Effect of Hydration and Dehydration on Renal Function in Surgical Patients

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The prohibition of oral fluids after midnight of the day preceding surgery is a common hospital practice. The negative water balance resulting from the failure to replace insensible and urinary losses which continue during the eight to twenty hour period before operation can be expected to produce a contraction of total body water that will be both intra- and extra-cellular in view of the hypotonic nature of fluids lost. Such acute volume depletion produces marked changes in cardiac and renal function.

The heart responds with a decrease in cardiac output, the kidney by a fall in renal plasma and urinary flow. The fall in glomerular filtration rate is usually blunted, probably by the phenomenon of autoregulation, which minimizes

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changes over a wide range of perfusion pressures.A patient who has been deliberately dehydrated would therefore appear to be at greater risk from the usual deleterious effects on renal function of subsequent anesthesia and surgery. In this study, several renel functions were measured throughout the operative and post-operative periods in a small group of patients hydrated before surgery and in a group that underwent the usual pre-operative dehydration.

The ages of patients and the extent of the surgical procedures were roughly comparable between both groups (Tablel).

A. catheter was placed in the urinary bladder on the day prior to surgery. Preoperative meperidine and atropine were given intravenously prior to balanced anesthesia with thiamytal,succinylcholine,nitrous oxide-oxygen,meperidine and d-tubocurarine. Both groups received lactated Ringer's solution intraoperatively at a rate of 5 ml/ Kg / hr. Blood losses were minimal and replaced with 3 volumes of lactated Ringer's solution for one volume of blood. After discharge from the recovery room, all patients received 10% glucose in ½ normal saline at a rate of 125 ml/hr until the end of the study.

Renal function was assessed serially on 5 occasions in each patient: 1) on the day prior to surgery 2) one hour prior to the induction of anesthesia 3) intraoperatively 4) in the immediate recovery period and5) 24 hours after the completion of surgery.

The parameters determined were: 1) effective renal plasma flow (ERPF) and glomerular filtration rate (GFR) by a single-dose injection technique with 131-I orthiodohippurate and 125-I iothalamate. 2) urinary and plasma osmolalities by freezing point depression (Fiske Osmometer). 3

urinary flow rate. 4) plasma and urinary sodium concentrations (Technicon AutoAnalyzer).

From the above determinations were calculated: 1)filtr-

Table 1a

Period	Duration (Hr)	Fluid (ml)	Procedure	AGe Sex	GFR (ml/min)	ERPF (ml/min)	FF	Ccr (ml/min)	Uosm (mosm)	Cosm (ml/min)	CH_2o (ml/min)	V (ml/min)	UnaV (Ueg/min)	TNa (%)
I	15./2	2.125			93	316	.29	106	672	1.4	+0.1	2.0	168	99.5
II	2	325		56	54	107	.50	124	428	5.3	-1.6	3.7	620	91.9
III	2	600	Bladder	0	136	439	.31	90	570	2.0	-0.9	1.1	232	98.8
IV	2	500	Suspension	+	62	144	.43	50	491	2.8	-1.7	1.1	232	96.0
V	24	3.000		(R.E.)	162	400	.41	196	128	2.8	-1.2	1.6	14	99.7
I	10	1.250			62	278	.22	63	452	1.4	+0.1	1.5	116	99.2
II	2	250		72	56	219	.26	53	406	1.2	+0.1	1.3	144	98.7
III	3	750	Urethro-	♂	70	318	.22	66	242	1.8	-0.3	1.5	87	98.8
IV	2	200	plasty		59	193	.31	55	429	3.1	-1.0	2.1	353	95.7
V	24	3.000		(C.L.)	65	227	.29	74	187	0.8	+1.2	2.0	34	99.8
I	10	1.000			93	303	.31	116	503	3.4	-1.5	1.9	297	97.7
I	2	300		46	88	281	.31	71	113	1.6	+2.1	3.7	77	99.3
III	4	1.400	Abdominal	0	201	1033	.19	113	583	2.0	-1.3	0.7	101	99.5
IV	2	250	Hysterectomy	+	124	267	.46	118	723	3.7	-1.9	1.8	435	97.8
V	24	3.000		(G.H.)	152	373	.41	105	338	1.4	+0.3	1.7	81	99.7
I	17./2	2.400			101	217	.46	173	167	2.2	-o.7	1.5	47	99.1
II	3	500		48	129	275	.46	112	260	3.4	-1.1	2.3	185	98.3
III	3	1.400	Abdominal	0	130	731	.17	99	542	1.2	-0.5	0.7	81	99.5
IV	2	700	Hysterectomy	+	101	200	.50	82	626	2.0	-1.1	0.9	170	98.7
V	24	3.000		(C.M.)	258	724	.35	228	545	2.9	-1.0	1.9	301	99.3
Mean														
I	13	1.700			87	279	.32	115	449	2.2	-0.5	1.7	157	98.9
II	2	350		55	82	221	.38	40	302	2.9	-0.1	2.8	257	97.1
III	3	1.050			134	630	.22	92	484	1.8	-0.8	1.0	123	99.2
IV	2	400			87	201	.43	76	567	2.9	-1.4	1.5	298	97.1
V	24	3.000			160	431	.37	151	300	2.0	-0.2	1.8	108	99.6

Individual Results of Patients of Group I (Hydrated) ation fraction (FF) from GFR/ERPF. 2) osmolar clearances (Cosm) from urinary osmolality x urinary flow rate (in ml / min) divided by plasma osmolality. 3) free water clearance (CH_2o)from V-Cosm 4) fractional reabsorption of sodium (FNa)from 100-urinary sodium excretion (mEq/min) divided by filtered sodium load (GFR $\frac{\text{X plasma}}{1000}$ sodium).

Materials and Methods

Eight patients scheduled for elective major abdominal surgery usually requiring an indwelling urinary catheter were selected.

The purpose of the study was explained and consent Obtained. Four patients received an intravenous infusion of 10% glucose in ½ normal saline at a rate of 125 ml/hr during the 10 to 18 hour period preceding surgery. This solution was chosen to provide calories as well as a hypotonic fluid load. Four other patients were deprived of fluid from mid night of the day preceding surgery.

RESULTS

The changes in all parameters are shown in Table 1. The most marked differences were between the renal hemodynamics of dehydrated and hydrated groups, when the two preoperative values were averaged and compared to those obtained during surgery. GFR and ERpF rose 55 and 170 % in the hydrated group ad compared to a fall of 10 and 28 % in dehydrated patients (Table 2). These changes were statistically significant to a p value of less than 0.05. The FF decreased to a normal value during surgery in the hydrated patients but remained elevated in those that had been subjected to water deprivation.

Table 1b

Period	Duration (Hr)	Fluid (ml)	Procedure	AGe SeX	GFR (ml/min)	ERPF (ml/min)	FF	Ccr (ml/min)	Uosm (mosm)	Cosm (ml/min)	CH_2o (ml/min)	V (ml/min)	UnaV (Ueg/min)	Tubular Na Reobsorb
I	10	-			104	310	.34	133	931	1.8	-0.7	1.1	226	98.5
II	2	250	Bl adder	43	107	247	.43	101	544	1.8	-0.8	1.0	124	99.2
III	3	750	Suspension	0	109	310	.35	99	543	1.2	-0.4	0.8	78	99.5
IV	2	400		+	113	331	.34	96	679	1.6	-0.8	0.8	153	99.0
V	24	3.000		(A.G)	135	421	.32	123	141	1.8	+1.3	3.1	43	99.8
I	9	-			87	397	.22	95	889	1.0	-0.6	0.4	44	99.6
II	4	550	Vaginal	39	194	892	.22	127	350	3.4	-1.1	2.3	219	99.0
III	3	1,200	Hysterectomy		122	359	.34	82	620	3.1	-2.4	0.7	146	98.3
IV	2	200		+	156	517	.30	79	618	3.6	-1.5	2.1	481	98.3
V	24	3,000		(P.S)	99	550	.18	116	334	3.5	-1.5	2.0	222	97.5
I	11	-			122	311	.36	121	692	2.2	-1.3	0.9	92	99.4
II	2	100	Exploratory		165	609	.27	183	823	1.9	-1.1	0.8	82	99.7
III	3½	1,200	Laparotomy and	46	137	427	.32	137	770	1.1	-0.6	0.5	50	99.8
IV	2	200	Lysisof	+	91	310	.29	86	805	0.7	-0.5	0.25	19	99.8
V	24	3.000	Adhesion	(W.S)	255	1251	.20	241	912	2.1	-1.4	0.7	85	99.4
I	9½	-	Exploratory		98	565	.17	133	629	1.5	-0.8	0.7	139	98.9
II	3½	350	Laparotomy	69	62	261	.24	53	639	0.8	-0.5	0.3	44	99.4
III	2	700	and	0	52	205	.25	44	640	0.8	-0.4	0.4	51	99.3
IV	2	250	Oophorectomy	+	106	358	.30	50	350	1.5	-0.3	1.25	57	99.6
V	24	3.000		(P.E.)	74	199	.37	68	257	0.7	+0.1	0.8	30	99.5
mean														
I	10	-		49	100	396	.27	121	785	1.6	-0.8	0.8	125	99.1
II	3	300		46	132	502	.27	116	589	2.0	-0.9	1.1	117	99.3
III	3	950			105	325	.32	91	643	1.6	-1.0	0.6	81	99.2
IV	2	260			116	379	.31	104	613	1.9	-0.8	1.1	177	99.2
V	24	3,000			141	605	.23	137	411	1.8	-0.15	1.65	95	99.1

Individual Results of Patients of Group II (Dehydrated)

Change of Renal Clearances During Anesthesia and % Differences from Control

	Groups	Control	During Anesthesia	% Difference	Difference between groups	P Value
GFR	Hydrated gr.	85	134	+55%	65%	P<0.05
	Dehydrated gr.	116	105	-10%		
ERPF	Hydrated gr.	250	630	+170%	200%	P<0.05
	Dehydrated gr.	450	325	-28%		
F.F.	Hydrated gr.	.35	.22	-37%	50%	P>0.05 <0.10
	Dehydrated gr.	.27	.27	+14%		

(Tablr II)

Preoperative hydration was associated with a higher urine flow and lower urinary osmolality not only before surgery but during operation as well.The mean values were 1.0 ml/min and 484 mOsm/Kg in the hydrated patients as contrasted to 0.6 ml/min and 643 mOsm/Kg for the dehydrated group. The difference in free water clearance between groups was not, however, significant.

The urinary excretion and tubular rejection of sodium were, as expected, higher during the immediate pre - operative period in hydrated patients but there was little difference between groups during surgery. The urinary sodium and tubular rejection of sodium rose to the immediate period. Differences between groups in the renal handling of sodium were no longer evident on the first postoperative day.

Discussion

A moderate depression of renal function has been demonstrated in patients who received a variety of pre-anesthetic medications.

The usual changes have been a fall in ERPF, GFR and urinary flow rate and sodium excretion. The induction of anesthesia is usually accompanied by a further fall in these parameters which has been found to occur with such agents as ether,6 cyclopropane,7 halothane,8 thiopentel,6 and epidural lidocaine,9 Nevertheless, renal function is not always impaired by surgery.Thus,in a series of 24 patients undergoing cardiovascular surgery with light ether anesthesia the GFR and ERPF decreased in only half,1 0 The GFR and filtration fraction may even be modestly elevated following chest and lesser abdominal operations although a marked decrease in ERPF and GFR is the rule when abdominal surgery is more extensive,11 The use of cardiopulmonary , with or without hemodilution perfusion, bypass is associated with a fall in ERPF and GFR, 12. In the present study both GFR and ERPF decreased in each of the dehydrated patients during the intraoperative period.

The effect of preoperative hydration on subsequent changes in renal function had been studied previously. The replacement of 1/3 normal saline in 3.3% glucose in a volume equivalent to the previous night's urinary loss plus 10ml/Kg body weight during an hour period preceding anesthesia was associated in 6 patients with mean values of ERPF of 471, 415 and 251 during the control period and light and deep halothane anesthesia, respectively. The values for GFR were 91, 84 and 55. (13) In dehydrated patients, the values for ERPF were 550, 213, 168 and for GFR 114, 59 and 48.

It was apparent that hydration in the immediate pre - operative period was effective in minimizing the renal response to anesthesia and surgery.

In another study, 8 patients received 1 liter of 0.9% saline in an 8 hour period preceding surgery while 8 other patients were deprived of fluids. 14 The urine flow rate during the first 24 hours after surgery in the group that received saline was 1.4 as contrasted to 0.4 ml/min in dehydrated patients. The serum creatinine 24 hours after surgery showed little change from the pre-operative value of 0.5 mg /dl in the dehydrated patients but fell from 0.72 to 0.66 in patients who received preoperative volume expansion. The results of the current study suggests that intraoperative renal function can not only be maintained but improved by prior hydration.

The drop in urinary flow rate that accompanies anesth - esia and surgery cannot be explained entirely by a fall in GFR and consequent decrease in the filtered load of water presented to the tubules for absorption. Most changes in urine flow are in fact reflections of changes in antidiuretic hormone (ADH) activity.

Plasma ADH levels have been shown to increase with halothane [15] and methoxyflurane [16] anesthesia as well as during extracorporeal circulation.[17] Attempts to block the ADH response by intraoperative volume expansion with lactated Ringer's solution were unsuccessful since infusions even at the rate of either 5 or 15 ml/Kg/hr failed to prevent a rise in urinary vasopressin on the day of surgery. [18]

Although ADH levels were not measured in the present study the maintenance of a higher flow rate of urine with a lower osmolality in the hydrated group of patients suggests the possibility that the hypotonic stimulus provided by the preoperative fluids may have blunted the ADH response.This conclusion is strengthened by the finding that GFR did not fall in hydrated patients since it has been demonstrated that even when ADH is suppressed, a hypertonic urine can be produced if the GFR is lowered.

Changes in the renal excretion of sodium are usually effected by one of three mechanisms,a change in GFR,a change in the proximal tubular handling of sodium under the influence of a " natriuretic factor " and a charge in aldosterone secretion rate. Preoperative hydration was not effective in preventing the intraoperative increase in sodium reabsorption even though the component due to a decrease in GFR was eliminated. It is likely a decrease in effective circulating volume was responsible for the sodium retaining state since this provides a potent stimulus for the inhibition of natriuretic factor [19] and for the secretion of aldosterone as mediated by the renin-angiotensin system.[20]

This study indicates that preoperative hydration can have an apparently beneficial effect on renal hemodynamics investigators, these results would support the routine use of preoperative hydration in surgical patients.

Abstract:

Renal function was assessed before , during and after light balanced general anesthesia for abdominal surgery in 8 patients receiving intraoperative volume expansion with lactated Ringer's solution. Four patients received no fluids from midnight until the time of surgery ; the other four patients received hypotonic fluids at the rate of 125 ml / hr from the evening before surgery. Urine flow was higher and urine osmolality was lower in the hydrated group. Renal plasma flow and glomerular filtration rate rose significantly (p H 0.05) and filtration fraction fell (P H 0.10) during the intraoperative period in the hydrated patients.

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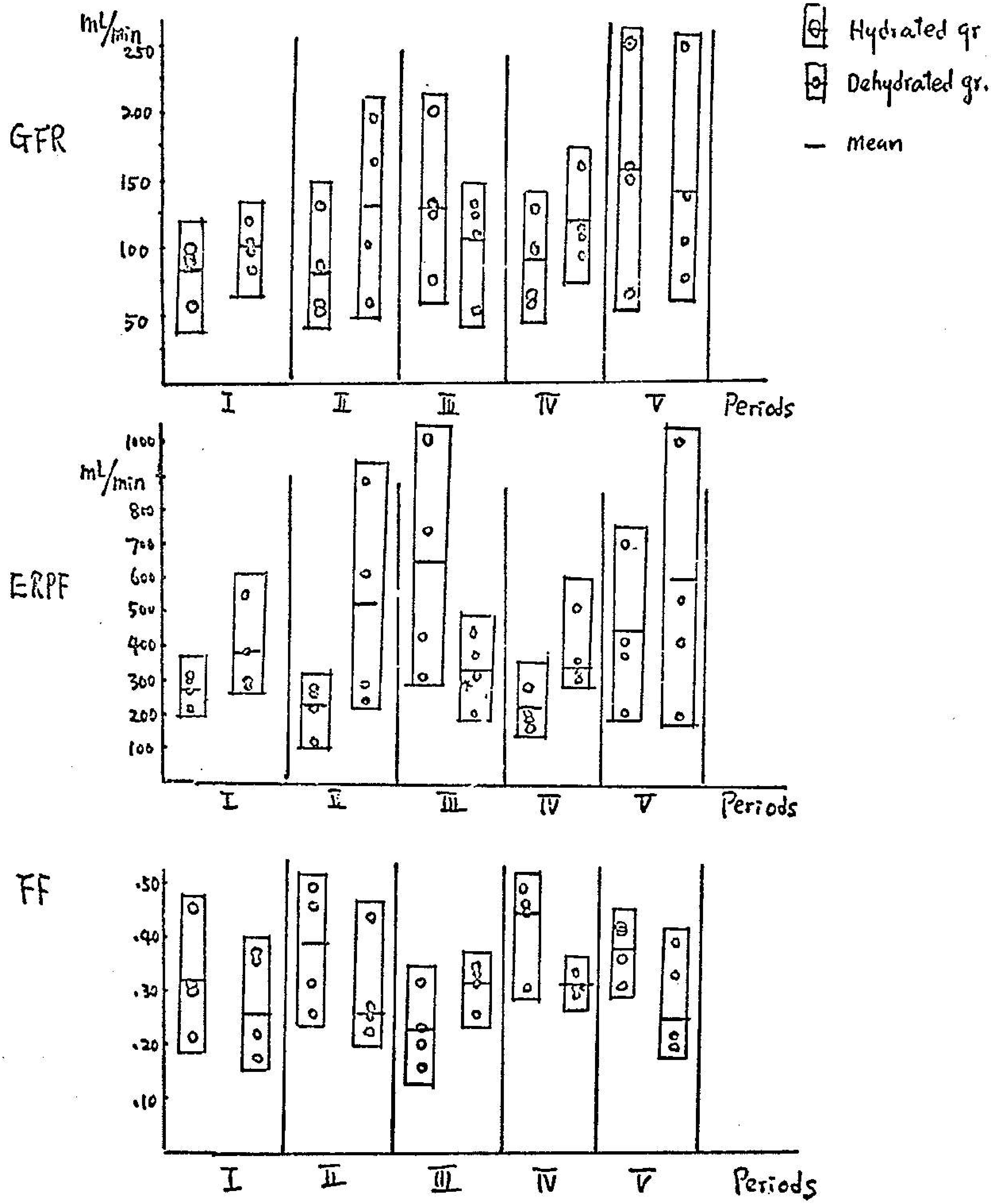
GFR
ml/min
250
200
150
100
50
Hydrated gr
Dehydrated gr.
mean
I
II
III
IV
V
Periods
ERPF
ml/min
1000
800
700
600
500
400
300
200
100
I
II
III
IV
V
Periods
FF
.50
.40
.30
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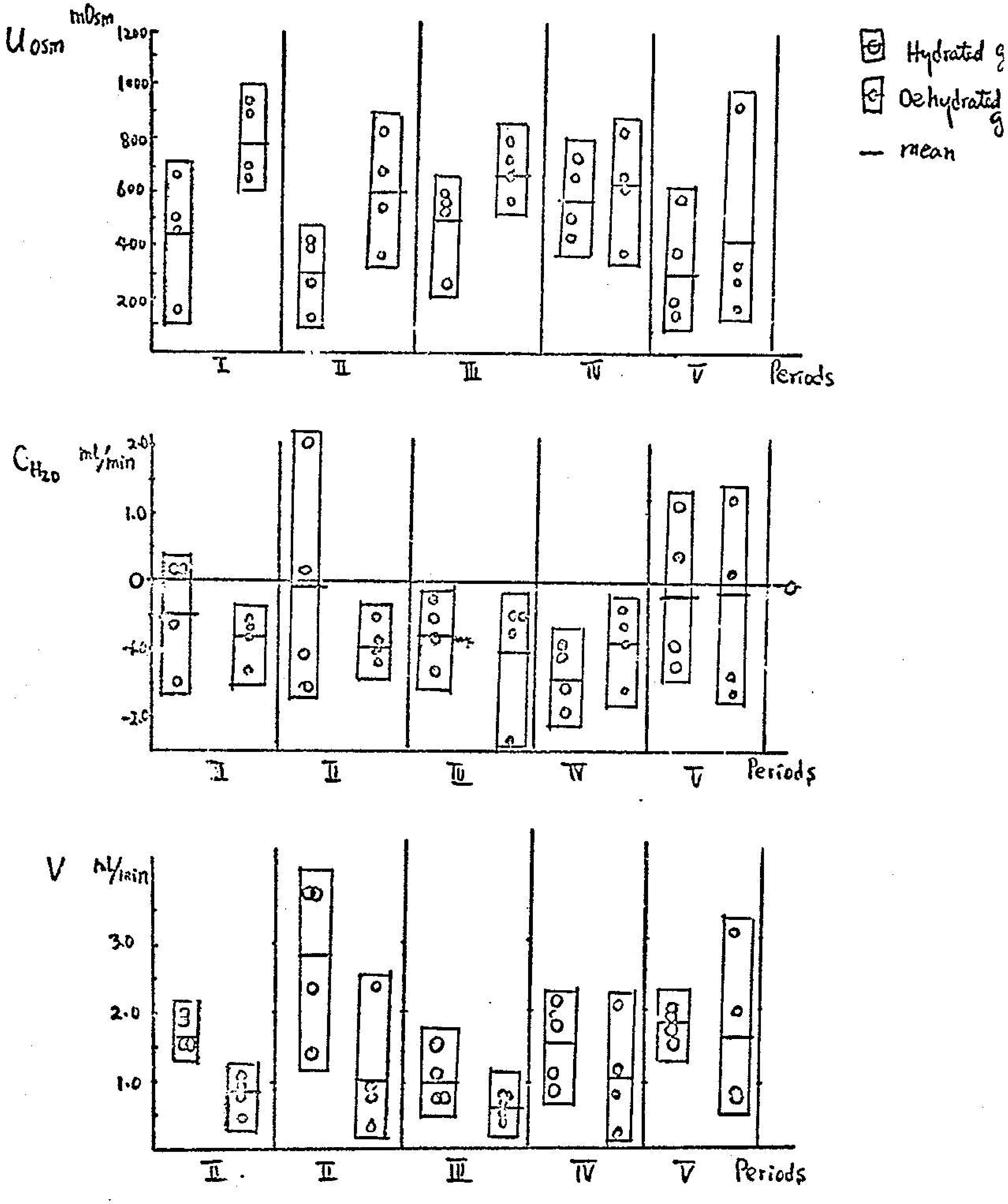
I
II
III
IV
V
Periods

<Graph 1>

1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I
II
III
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V
Periods
Hydrated g
Dehydrated g
— mean
C_{H_2O} ml/min
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1.0
0
-1.0
-2.0
V ml/min
3.0
2.0
1.0

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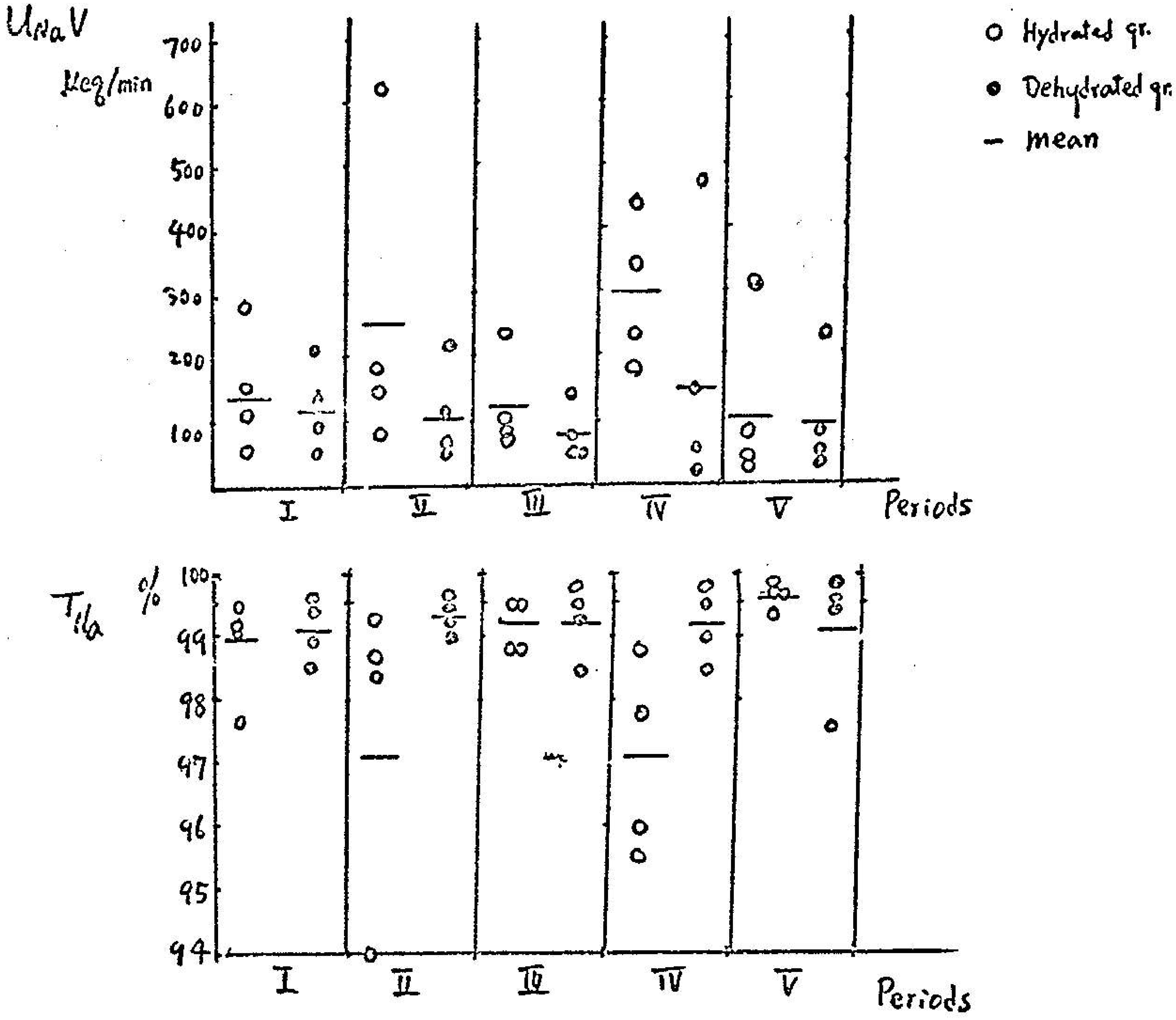

$U_{Na}V$
μeq/min
700
600
500
400
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o Hydrated gr.
• Dehydrated gr.
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I
II
III
IV
V
Periods
T_{Na}
%
100
99
98
97
96
95
94
I
II
III
IV
V
Periods

< Graph 3 >