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Changes in the Serum Concentrations of Sodium, Potassium, and Free Haemoglobin during Transurethral Resection of the Prostate – Parts of the TUR-Syndrome?

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Summary. In 133 patients undergoing transurethral resection of the prostate under standardized conditions the concentration of serum sodium decreased, and the concentration of free plasma haemoglobin increased significantly after the operation. Such changes were not found in a control group of 31 patients undergoing cystoscopy or bladder biopsy. The changes in the operated group are believed to be caused by the absorption of water used as irrigating fluid during the resection.

Key words: Transurethral resection - Fluid absorption - Free haemoglobin - TUR-syndrome.

During transurethral resection of the prostate (TURP) irrigating fluid may be absorbed from the resected cavity into the periprostatic space or into the blood stream via opened veins in the wall of the cavity. Several litres of fluid can be absorbed, of which 25% may enter the blood stream directly (13). The amount of absorbed fluid varies from patient to patient, depending among other things on the level of the irrigating fluid above the patient and thus on the pressure in the prostatic cavity, the time taken for the resection, the amount of resected tissue, and the skill of the resectionist (6, 10). The symptoms caused by absorption of irrigating fluid have been described as the TUR-syndrome. The nature of the irrigating fluid decides the severity and the individual symptoms of the syndrome (3, 4, 6). If plain water is used, intravascular haemolysis may follow absorption, but overhydration, changes in the electrolyte concentrations of the plasma, and bacteraemia have also been mentioned as causes of the syndrome. A variety of methods have been used to demonstrate absorption of irrigating fluid such as measurements of electrolytes and free haemoglobin in the plasma, the central venous pressure, increase in the patient's weight, and radioisotope studies (1, 4, 8, 11, 13).

Absorption may take place in spite of a careful technique and lead to dangerous consequences. After having seen two cases of clinically evident TUR-syndrome, we decided to investigate whether or not simple methods could reveal the absorption of irrigating fluid during TURP under standard conditions.

MATERIAL AND METHODS

The investigation comprises 133 consecutive patients subjected to transurethral resection of the prostate, and as a control group 31 male patients subjected to transurethral instrumentation but without resection of the prostate (cystoscopy, bladder biopsy, and resection of papillomas of the bladder).

The average age of the TURP-patients was 67 years (30-90 years), and of the control group 64 years (50-78 years). Nine patients had a cancer of the prostate, in all other patients microscopic examination of the resected tissue showed benign hyperplasia. Venous blood was withdrawn for measurement of the

Table 1. Serum concentrations of Na, K, and free plasma haemoglobin in patients undergoing transurethral resection of the prostate

	Number of patients	Mean values Preop.	Postop.	24h postop.	Paired t-test	Range of differences Increase	Decrease
	128	139.8	136.1		significant	6	21
Na	130	139.8		136.3	significant	9	12
(mmol/l)	127		136.1	136.3	insignificant	17	9
	128	3.9	4.0		insignificant	1.9	1.5
K	130	3.9		3.6	significant	0.6	2.0
(mmol/l)	127		4.0	3.6	significant	0.8	1.5
Free plasma	121	4.5	30.5		significant	429.0	21.6
haemoglobin	112	4.9		8.2	significant	47.0	26.0
(mg/100 ml)	115		28.7	8.0	significant	36.5	421.0

The significance level ($P < 0.05$) is based on paired t-test on the differences from preop. to postop. values in each patient.

Table 2. Serum concentrations of Na, K, and free plasma haemoglobin in the control group

	Number of patients	Mean values Preop.	Postop.	24h postop.	Paired t-test	Range of differences Increase	Decrease
	31	138.7	137.3		insignificant	10	11
Na	28	138.7		138.0	insignificant	9	6
(mmol/l)	28		137.1	138.0	insignificant	10	10
	31	3.9	4.0		insignificant	0.7	0.8
K	28	3.9		3.9	insignificant	0.8	0.8
(mmol/l)	28		3.9	3.9	insignificant	0.8	0.9
Free plasma	29	3.3	7.9		insignificant	68.8	5.3
haemoglobin	24	3.3		7.6	insignificant	68.1	6.1
(mg/100 ml)	25		7.6	7.3	insignificant	72.3	70.8

The significance level ($P < 0.05$) is based on paired t-test on the differences from preop. to postop. values in each patient.

serum concentrations of sodium, potassium, free haemoglobin, and haptoglobin immediately before and immediately after the operation, and 24 h after surgery. Blood was obtained from the opposite arm from the intravenous infusion. During surgery a slow infusion of isotonic glucose or sodium chloride was given. Blood transfusion was given to fourteen patients. At the conclusion of the resection, furosemide was given intravenously to 84 patients at the same time as the second blood sample. In all cases the irrigating fluid used was sterilized plain water of room temperature, with a maximum height above the operation table of 60 cm. Inhalation anaesthesia was used in most patients, but a few underwent spinal anaesthesia.

RESULTS

In the TURP-patients the mean time for resection was 56 min and the mean volume of resected tissue was 7.7 cc. In the control group the time of instrumentation was 19 min and less than 1 cc of tissue was removed. The serum concentrations of sodium, potassium, and free haemoglobin in the TURP-patients are shown in Table 1, and in the control group in Table 2. The changes in concentrations show normal distribution (χ^2-test). For statistical analysis paired t-test of the differences has been used with a level of significance of 0.05. The Wilcoxon-test gave the same results as the t-test in all cases. In most patients only small changes from preoperative to postoperative values were observed, but in some patients the changes were great. The mean concentrations therefore do not show great variation, but in the TURP-patients significant changes were found in the differences between the pre- and post-operative values of serum sodium and free haemoglobin (Table 1), whereas such changes in the differences were not found in the control group (Table 2). The injection of furosemide postoperatively in 84 patients did not influence the changes in serum sodium concentrations. The lowest concentration of serum sodium found was 116 mmol/l postoperatively in a patient with normal values preoperatively. All except two patients had concentrations of serum potassium within normal limits (3.6 - 5.1 mmol/l).

The highest concentration of free plasma haemoglobin found was 440 mg/100 ml immediately after the operation. In this patient serum sodium decreased from 142 mmol/l preoperatively to 132 mmol/l postoperatively. Serum potassium was unchanged, while serum haptoglobin decreased from 2.31 g/l preoperatively to 0.15 g/l 24 h after the operation. It appears from Table 3 that 42 (33%) of the TUR-patients had concentrations of free plasma haemoglobin above 15 mg/100 ml postoperatively, compared to only 2 patients (6%) in the control group. Of the TURP-patients 23 (18%) had concentrations above 50 mg/100 ml postoperatively, and 8 patients (6%) above 100 mg/100 ml.

We found a degree of correlation between these plasma concentrations of free haemoglobin and the time used for the transurethral resection. In the group of patients with a postoperative free plasma haemoglobin below 10 mg/100 ml, the mean time used for the TURP was 45 minutes with a range of 10-120 minutes. In the group of patients with postoperative free plasma haemoglobin between 10 and 50 mg/100 ml, the mean time used was 56 minutes with a range of 15-150. In the 23 patients with postoperative concentrations above 50 mg/100 ml the mean time used for the TURP was 66 minutes, with a range of 30-210. On the other hand we found no correlation between the postoperative concentration of free plasma haemoglobin and the amount of resected prostatic tissue.

Another expression of haemolysis is the concentration of haptoglobin in the plasma. We used an immunological method for the determination of haptoglobin (Laurell) measuring free as well as blocked haptoglobin, and we were unable to show significant changes in the concentrations. This may be due to the method used, but we consider the haptoglobin concentration to be a poor expression of acute haemolysis.

Table 3. Concentrations of free plasma haemoglobin immediately postoperatively in patients undergoing transurethral resection of the prostate (TURP), and in the control group

Free plasma haemoglobin mg/100 ml	TURP		Control	
	No.	Percent	No.	Percent
< 15	85	67[a]	29	94
15 - 50	19	15	1	
51 - 100	15	12	1	
> 100	8	6	0	

[a] $P < 0.01$

DISCUSSION

During transurethral resection of the prostate changes occur in the composition of the plasma. A decrease in the concentration of sodium which we found in our TURP-patients, but not in our control group, can be explained by absorption of irrigating fluid into the circulation (dilution of the plasma) (1, 6). Some investigations have shown that the plasma volume remains unchanged or even decreases during TURP (2, 11), which might suggest that the absorbed fluid is rapidly distributed within the extracellular space or total body water. New and accurate determinations with a double isotope technique have shown that about 25% of the absorbed fluid enters blood vessels and about 75% pass into the perivesical space (13). Our investigation showed a significant decrease in the concentration of serum sodium during and after TURP but did not show the reason for this decrease. Considered together with the increase in the concentration of free plasma haemoglobin, however, fluid absorption becomes the most probable explanation. Following the occurrence of a very low postoperative concentration serum sodium returns to normal slowly. This might be caused by the continuing absorption of fluid from the perivesical space. In consequence, the treatment of the TUR-syndrome should be hypertonic NaCl-infusion and diuretics in the first 24-48 h after the operation, when the absorption of irrigating fluid is suspected (7).

In our investigation as well as in others no significant change in the serum potassium concentration during TURP was shown. A severe increase in potassium concentration (up to 9.8 mmol/l), followed by cardiac arrest has been reported in one patient who had a concentration of free plasma haemoglobin of 1350 mg/100 ml (9). The reason for this large increase in concentration of serum potassium could be severe intravascular haemolysis. Dilution of the plasma may prevent an increase in the serum potassium concentration in the presence of haemolysis. In the 23 patients with a rise in free plasma haemoglobin to over 50 mg/100 ml, the concentration of serum potassium only increased by an average of 0.2 mmol/l. Hypotonic irrigating fluids carry the risk of haemolysis of erythrocytes either in the prostatic cavity or intravascularly (4, 9). After the use of distilled water as irrigating fluid during TURP, a significant increase in the concentration of free plasma haemoglobin has been reported by others. Creevy (4) found a mean increase of 42 mg/100 ml during TURP, and Madsen et al. (9) found increases of up to 118 mg/100 ml. Our investigation showed a mean increase from pre- to postoperative values of about 26 mg/100 ml. 22% of our TURP-patients had an increase of between 10 and 50 mg/100 ml, 12% to between 51 and 100 mg/100 ml, and 6% increased to above 100 mg/100 ml. In 20% of his patients Goodwin (5) showed an increase in the concentration of free plasma haemoglobin to above 100 mg/100 ml. The reduced frequency of such great increases in our material can probably be ascribed to present day knowledge of the problem and the use of a low irrigating fluid pressure and short resection time. This risk is eliminated if isotonic irrigating fluids are used, now recommended by several investigators (6, 9). To avoid the excessive absorption of irrigating fluid during TURP we would recommend 1) greater attention to the problem by the surgeon and the anaesthetist; 2) the maximum level of the fluid should be at 60 cm above the patient; 3) the use of isotonic irrigating fluids if the resection is expected to be of long duration and/or to be performed by an inexperienced surgeon. If spinal anaesthesia is used, the early symptoms of the TUR-syndrome can be observed, and the resection concluded rapidly. Determinations of serum sodium and free plasma haemoglobin may provide useful confirmatory evidence of fluid absorption.

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