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 renal 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 (Table1).

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 thiamytail, 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 1/2 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 and 5) 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 orthiodipurpurate and 125-I iothalamate. 2) urinary and plasma osmolalities by freezing point depression (Fiske Osmometer). 3
Table 1a

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<th>Fluid</th>
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<th>Age (yr)</th>
<th>Sex</th>
<th>Ccr (ml/min)</th>
<th>Fe (mg/ml)</th>
<th>Uroman (mg/ml)</th>
<th>Chro (mg/ml)</th>
<th>Creatinine (mg/dl)</th>
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The Effect of Hydration and...
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 (CH2o) from V-Cosm 4) fractional reabsorption of sodium (FNa) from 100 urinary sodium excretion (mEq/min) divided by filtered sodium load (GFR X plasma 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 midnight 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>
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<tr>
<th>Procedure</th>
<th>Sex</th>
<th>Age</th>
<th>ESR (mm/h)</th>
<th>Hb (g/dL)</th>
<th>PCV (%)</th>
<th>Haemoglobin (g/dL)</th>
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Table 1: Indirect Results of Patients of Group II (Diagnosed)
### Change of Renal Clearances During Anesthesia and % Differences from Control

<table>
<thead>
<tr>
<th>Groups</th>
<th>Control</th>
<th>During Anesthesia</th>
<th>% Difference</th>
<th>Difference between groups</th>
<th>P Value</th>
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<td>GFR</td>
<td>Hydrated gr.</td>
<td>85</td>
<td>134</td>
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<td>Dehydrated gr.</td>
<td>116</td>
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<td>ERPF</td>
<td>Hydrated gr.</td>
<td>250</td>
<td>630</td>
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<td>Dehydrated gr.</td>
<td>450</td>
<td>325</td>
<td>-28%</td>
<td>200%</td>
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<tr>
<td>F.F.</td>
<td>Hydrated gr.</td>
<td>0.35</td>
<td>0.22</td>
<td>-37%</td>
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<td></td>
<td>Dehydrated gr.</td>
<td>0.27</td>
<td>0.27</td>
<td>+14%</td>
<td>50%</td>
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</table>

( Table 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 preoperative 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, cyclopropane, halothane, thiopentol, and epidural lidocaine. 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, 10 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. 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 preoperative 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 anesthesia 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 change 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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Graph 2

- **U_{osm}**: Osmolality in mOsm
- **C_{H2O}**: Water content in mL/min
- **V**: Volume in mL/min
Graph 3