

# Could Conductivity Be Used As A Parameter in Grinalaysis?

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## Abstract

Conductivity is a non-linear function of electrolyte concentration in solutions and could be used as an indirect method. The aim of this study was to determine the feasibility of urine conductivity measurement, which is a simple, cheap and not time consuming method, in the evaluation of renal functions. Seventy-two patients whose primary diseases were not taken into consideration were enrolled in this Study. Fiist morning urine specimens were obtained from all the patients and evaluated for osmolality, conductivity, pH, specific gravity, protein, creatinine, urea, uric acid, glucose, sodium, potassium, chloride, inorganic phosphate and calcium levels. There was a significant positive relation between osmolality and creatinine, urea, sodium, potassium, chloride, inorganic phosphate, uric acid, conductivity and specific gravity. Conductivity was also determined to be positively related to osmolaity ( $r:0.390$ ,  $p<0.01$ ), sodium ( $r:0.326$ ,  $p<0.01$ ) and uric acid ( $r: 0,345$ ,  $p <0.01$ ). The patients were grouped as those with a urine osmolality of less or more than 290 mOsm/kg. H<sub>2</sub>O (group A and B respectively). Urine conductivity was  $6.84\pm5.35(0.16-23-2)$  mScm' in group A and  $10.6\pm5.25 (0.12-192)$  mScm' in group B. The difference was statistically significant ( $p=0.005$ ). When the spectrum of conductivity values were evaluated separately in each group, 74% of the patients in group A and 33.9% of the patients in group B were determined to have a conductivity level of less than 7.338 mScm-1, In conclusion, urine conductivity has a positive relation with osmolality. In addition, while osmolality and specific gravity are effected by many non-electrolyte molecules, conductivity is only related to sodium and uric acid concentrations. In addition, urine osmolality and conductivity levels could be used to interpret the concentration of uncharged glucose molecules. These results suggest that conductivity could be used as a parameter in routine urinalysis (JPMA 48:238, 1998).

## Introduction

Urinalysis is a simple but important method used in evaluation of renal diseases and in differential diagnosis of systemic diseases affecting kidney. Determination of urine electrolytes is very important during the treatment of dehydration in childhood. However, the methods used for determination of urine solutes are time consuming and/or require expensive equipment. Urine osmolality and specific gravity which are used to evaluate renal concentration capacity could also reflect urinary electrolyte levels, however they are also effected by other non-electrolyte solutes<sup>1,2</sup>.

Conductivity is a non-linear function of electrolyte concentrations in fluids and can be used as an indirect method<sup>3</sup>. Whole process takes only about 30 seconds and no additional material is needed. The aim of this study was to evaluate the applicability of conductivity measurement, which gives results+ in a short time and does not require expensive equipment, for the determination of urine electrolytes.

## Materials and Methods

At least 60 ml of first morning urine specimens were obtained from 72 children without taking their primary diseases into consideration. Fifty ml of these urines were used to determine specific gravity and conductivity, while about 10 ml were used for biochemical analysis. Urine conductivity was

evaluated by “Conductivity and TDS meter, model 44600 (Hatch Company, Loveland, Colo USA)” in 50 ml of urine at room temperature (25°C) (Figure 1).

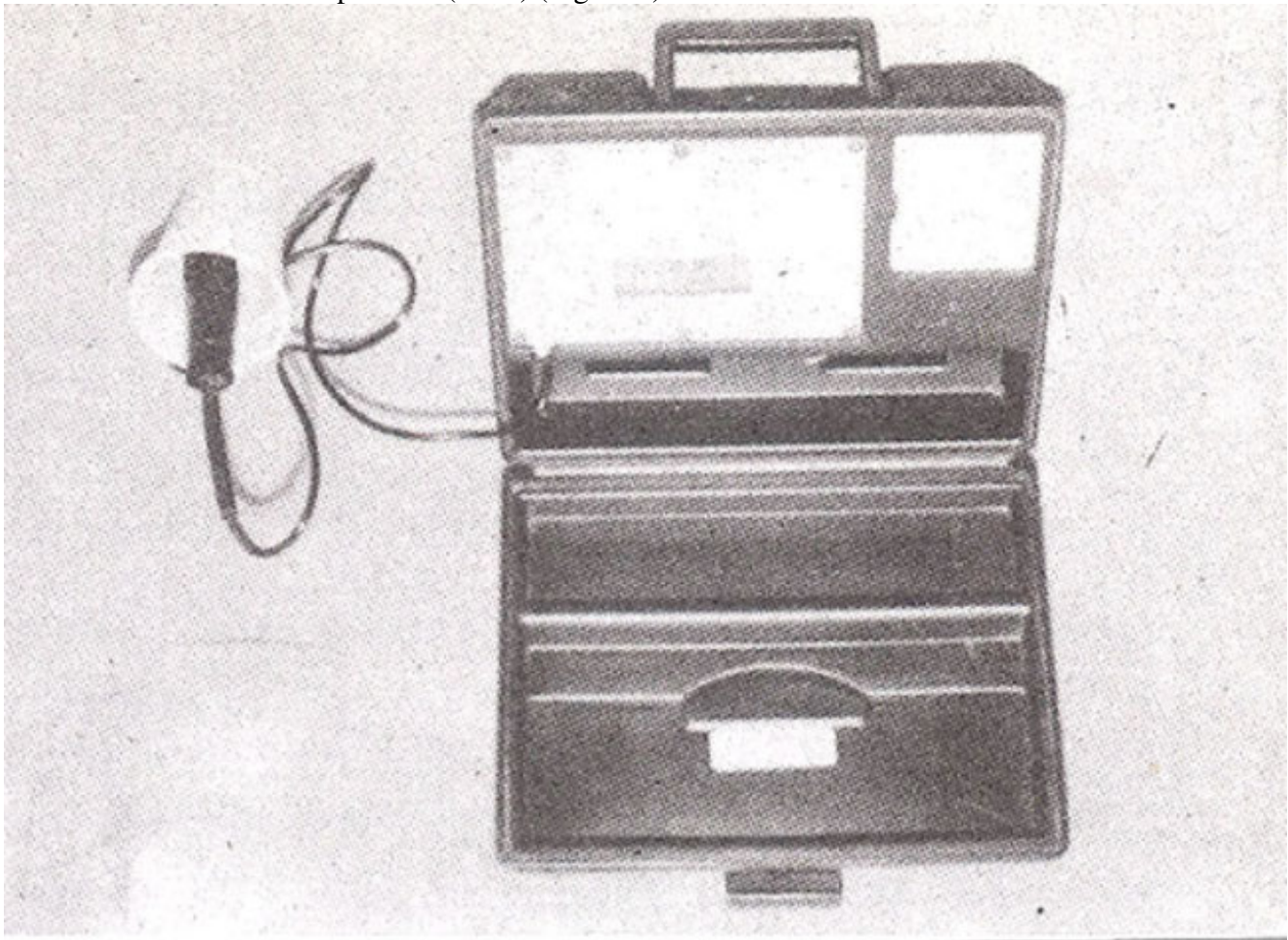


Figure 1. Conductivity and TDS meter” device.

Specific gravity was measured by densitometer at the same temperature and with the same urine sample used for conductivity determination. Urine osmolality was determined by “Osmotat 030-D (Gonotec, Berlin, Germany)” via cryoscopic method. Urine pH was evaluated by dipstick method, while protein, creatinine, urea, uric acid, sodium, potassium, chloride, glucose, calcium and inorganic phosphate levels were measured via spectrophotometric method by “DACOS XL autoanalyser”. Osmolality is effected by the positively charged (EP), negatively charged (EN) and uncharged ( $E^\circ$ ) molecules ma solution. However, conductivity reflects only the charged molecules in a solution. Thus, we can assume the following equations:

$$\text{Osmolality (O)} \text{ EP+EN+E}^\circ \text{ (1)}$$

$$\text{Conductivity (C)} \text{ EP+EN (2)}$$

$$\text{O/C EP+EN+E}^\circ/\text{EP+EN (3)}$$

$$\text{C}_x \text{ (EP+EN+E}^\circ) \text{ O}_x \text{ (EP+EN) (4)}$$

$$\text{E}^\circ \sim \text{O}_x \text{ (EP+EN) - C}_x \text{ (EP+EN)} / \text{C (5)}$$

Using the last equation(5) , we tried to evaluate the relation of the levels of uncharged molecules (glucose, urea, creatinine and proteins), singly or in combination, to  $E^\circ$ .

Statistical evaluation of the results were done by correlation analysis and unpaired student t test and p values less than 0.05 were accepted as statistically significant.

## Results

The mean, minimum and maximum values of all the parameters are shown in Table.

**Table. Mean, minimum and maximum levels of urinary solutes.**

|  | Mean±SD*     | Minimum | Maximum |
|--|--------------|---------|---------|
| Osmolality<br>(mOsm/kg.H <sub>2</sub> O) | 583.4±339.9  | 65      | 1194    |
| Specific gravity                         | 1014.5±5.7   | 1005    | 1030    |
| pH                                       | 5.50±0.78    | 5       | 8       |
| Conductivity (mScm <sup>-1</sup> )       | 9.1±5.5      | 0.12    | 23.24   |
| Protein (mg/dl)                          | 55.3±173.0   | 1       | 965     |
| Creatinine (mg/dl)                       | 71.4±46.9    | 3       | 223     |
| Urea (mg/dl)                             | 1553.8±910.8 | 535     | 3017    |
| Uric acid (mg/dl)                        | 26.8±23.9    | 1.4     | 97      |
| Glucose (mg/dl)                          | 15.0±26.1    | 0       | 103     |
| Sodium (mEq/l)                           | 114.0±61.9   | 9       | 234     |
| Potassium (mEq/dl)                       | 57.4±45.6    | 8       | 219     |
| Chloride (mEq/dl)                        | 142.6±71.0   | 13      | 332     |
| Calcium (mg/dl)                          | 7.1±6.3      | 0.7     | 27.8    |
| Phosphate (mg/dl)                        | 44.11±42.2   | 3.9     | 208     |

SD\*: Standard Deviation.

When the parameters used for the evaluation of renal concentration ability were correlated with the levels of osmotically active molecules in urine, significant positive relations were found between osmolality and creatinine (r:0.359, p<0.01), urea (r:0.854, p<0.001), sodium (r:0.326, p<0.01), potassium (r:0.475, p<0.01), chloride (r:0.321, p<0.01), inorganic phosphate (r:0.417, p<0.01), uric acid (r:0.390, p<0.01) and specific gravity (r:0.428, p<0.01).

While urine specific gravity was determined to be negatively correlated with pH (r:0.521, p<0.001), there was a positive correlation of specific gravity with creatinine (r:0.313, p<0.02), urea (r:0.347, p<0.01), chloride (r:0.339, p<0.01), calcium (r:0.262, p<0.01) and inorganic phosphate (r:0.475, p<0.01). Urine conductivity was positively correlated with osmolality (r:0.390, p<0.01) (Figure 2),

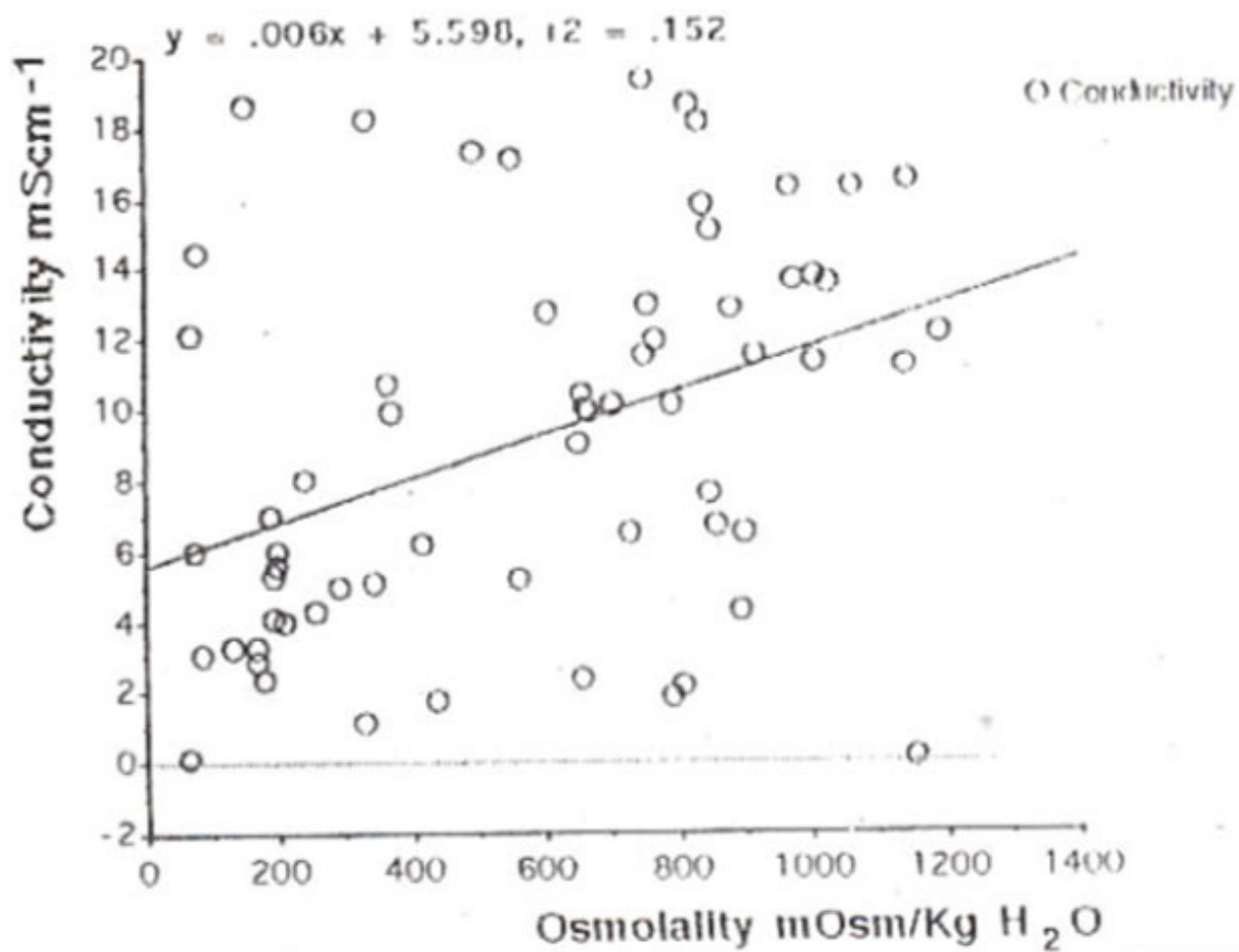


Figure 2. Relation between urinary osmolality and conductivity ( $r:0.390, p<0.01$ ).  
sodium  $r:0.268, <0.05$ ) (Figure 3)

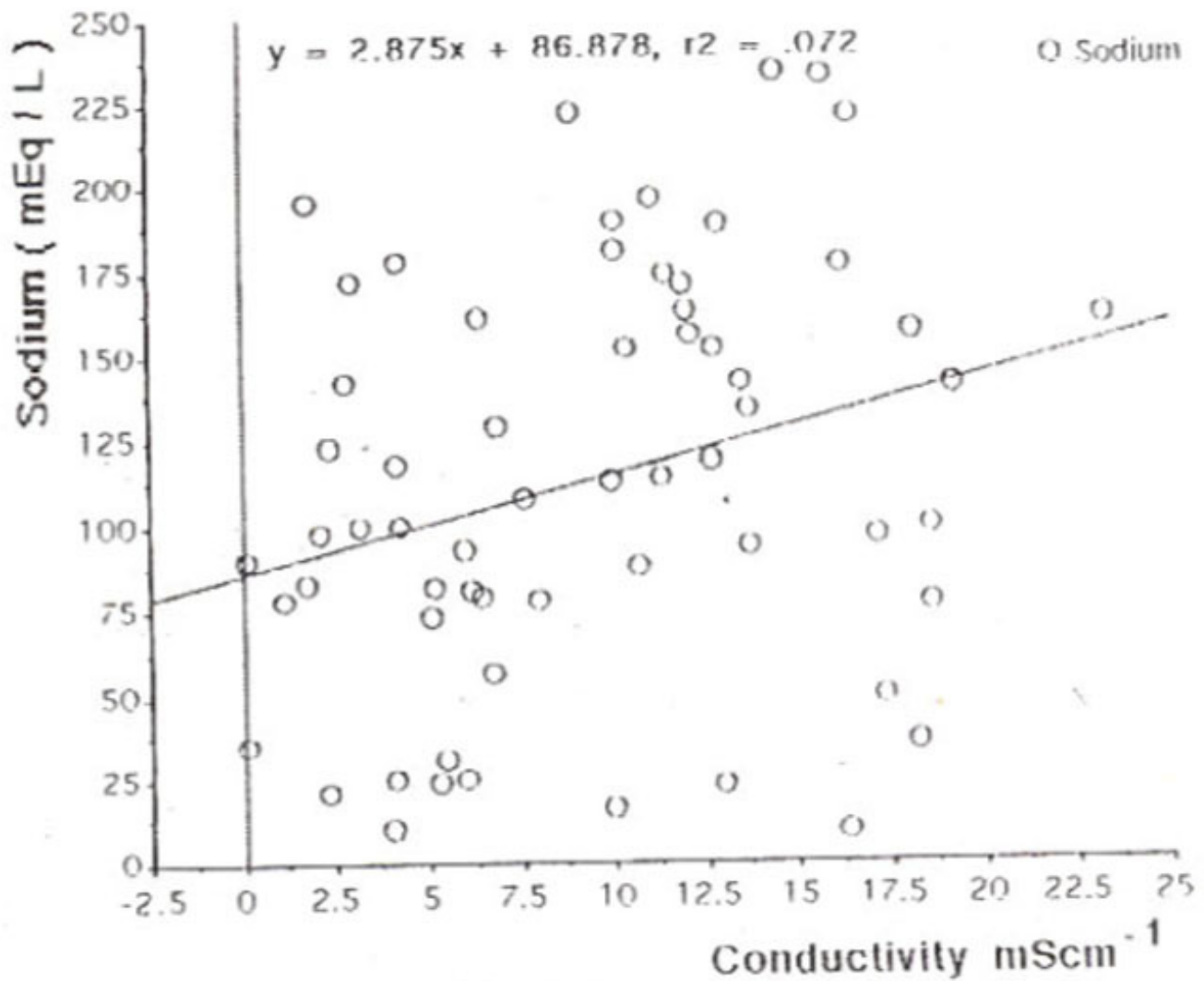
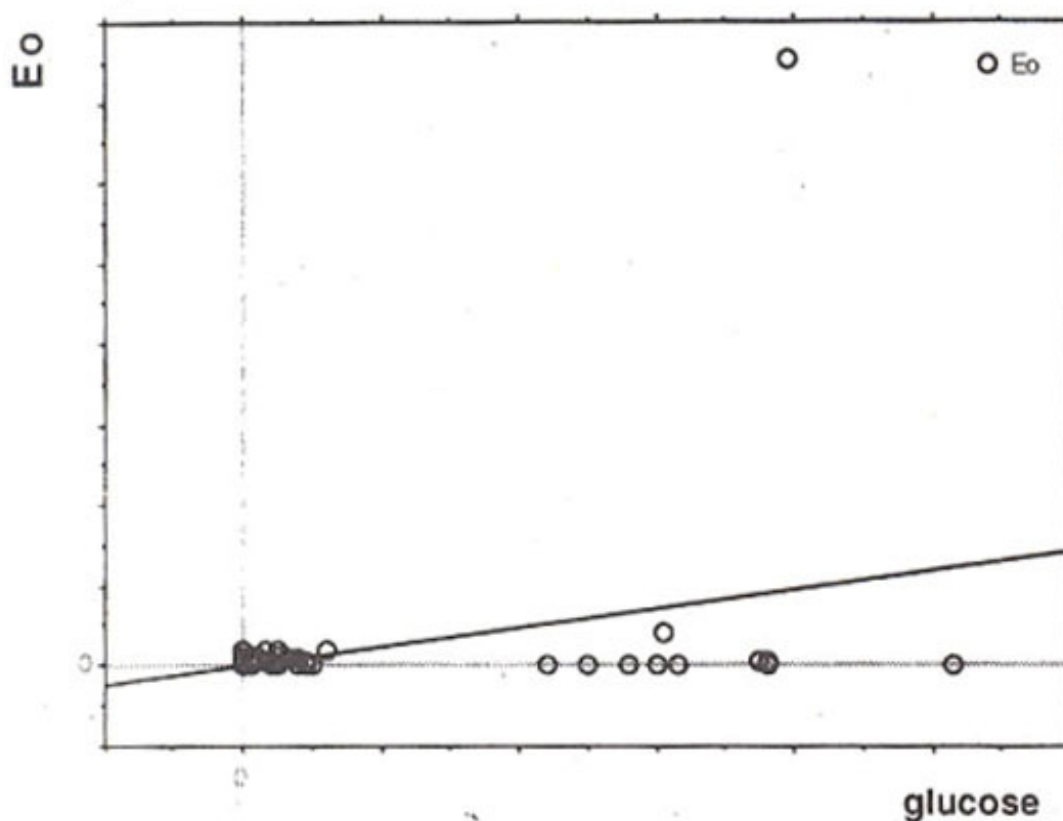


Figure 3. Relation between urinary conductivity and sodium ( $r:0.268$ ,  $p<0.05$ ).

and uric acid ( $r:0.345$ ,  $p<0.01$ ).

Only urine glucose levels were found to have a significant correlation with  $E^\circ$  using the equation 5 mentioned in methods ( $r:0.318$ ,  $p<0.05$ ) (Figure 4).



**Figure 4. Correlation of the urine glucose with uncharged urine molecules (protein, urea, creatinine, glucose).**

The sum of the uncharged molecules except glucose was unrelated to  $E^\circ$  ( $p > 0.05$ ). While glucose plus creatinine concentration was determined to be positively related to  $E^\circ$  ( $r: 0.338$ ,  $p < 0.02$ ), glucose plus urea and glucose plus protein concentrations were unrelated to  $E^\circ$ .

The patients were grouped as those with a urine specific gravity of less than 290 mOsm/kg. H<sub>2</sub>O (Group A) and those with more than 290 mOsm/kg. H<sub>2</sub>O (Group B). Urine conductivity was  $6.84 \pm 5.35$  (0.16-23.2) mScm<sup>1</sup> in group A and  $10.6 \pm 5.25$  (0.12-192) mScm<sup>1</sup> in group B. The difference of conductivity between two groups was statistically significant ( $p = 0.005$ ).

Conductivity value for osmolality of 290 mOsm/kg. H<sub>2</sub>O was determined to be 7.338 mScm<sup>1</sup> with the use of regression line. The ratio of patients with a conductivity of less than 7.338 mScm<sup>1</sup> was 74% in group A, while this ratio was 33.9% in group B.

Among the patients with a urine conductivity value of more than 7.338 mScm<sup>1</sup>, 88.9% were determined to have an osmolality of more than 290 mOsm/kg. H<sub>2</sub>O. Also, among the patients with less than 7.338 mScm. conductivity, 53.5% were identified to have an osmolality less than 290 mOsm/kg H<sub>2</sub>O.

## Discussion

Electrolyte concentrations in any solution can be measured indirectly via conductivity determination<sup>3</sup>. Conductivity should be measured at 25°C or be normalized for this temperature. Temperature coefficient is 0.021/°C and it is linear between 20 to 40°C<sup>4</sup>. On the other hand, osmolality gives more reliable results thermodynamically, since it is determined by the molecular weights of electrolytes without being dependent on temperature. In our study, all the urine samples were studied at 25°C to abolish the

effect of temperature differences on the results.

While high molecular weight substances like glucose, urea and proteins could alter osmolality and specific gravity<sup>2</sup>, conductivity is only determined by electrolytes<sup>5,6</sup>. In this study, while urine urea and creatinine concentrations were found to be positively correlated with osmolality and specific gravity, their relation with conductivity was insignificant. Uric acid, which is a weak acid, was determined to be positively related to osmolality and conductivity. Urinary protein leads to an increase of 3 units in specific gravity for every 10g/dl of protein concentration<sup>1</sup>. In our study, urinary protein concentration was determined to be unrelated to conductivity, specific gravity and osmolality. This result could be explained by the low protein levels in the urine samples used in this study. In other words, conductivity is not effected by the solutes other than electrolytes. However, determination of urine osmolality and conductivity gave us the opportunity to interpret urinary glucose concentration (Figure 4).

The cut off value of osmolality was accepted as 290 mOsm/kg.H<sub>2</sub>O. Corresponding conductivity value was calculated as 7.338 mScm<sup>-1</sup> by regression line. Among the urine samples with a conductivity level of over 7.338 mScm<sup>-1</sup>, 89.9% were determined to have an osmolality of over 290 mOsm/kg.H<sub>2</sub>O, while 53.5% of those urine samples with conductivity less than 7.338 mScm<sup>-1</sup> had an osmolality less than 290 mOsm/kg.H<sub>2</sub>O. This could be explained by the effect of non-electrolyte solutes on the osmolality.

While the price of osmometer device used to measure osmolality is 8000 DM, that of Conductivity and TDS meter is only 1350 DM. This device is used routinely in hemodialysis units. Our study demonstrated that it could also be used in routine urinalysis. Another advantage of this method is that it does not require any additional laboratory material.

In conclusion, it could be stated that urine conductivity and osmolality is positively related. However, conductivity is more reliable in determining the electrolyte concentration and is more practical. While urine osmolality and specific gravity are effected by solutes other than electrolytes, conductivity is only found to be related to sodium and uric acid. In addition, urine osmolality and conductivity levels could be used to interpret the concentration of uncharged glucose molecules. These results suggest that conductivity could be used as a parameter in urinalysis.

## References

1. Miller RB. Urinalysis. In: Textbook of Nephrology, 2nd edition, Masary SO., Glasscock RJ eds. Baltimore, Williams, Wilkins, 1989, pp 1588-89.
2. Freier EF. Osmometry, In: Textbook of clinical chemistry, Tietz NW ed. Philadelphia, WB Saunders Company, 1986, pp. 129-35.
3. Polashegg HD. On-line dialyserclearance using conductivity, *Pediatr. Nephrol.*, 1995;9:S9-S11.
4. Polashegg HD, Levin NW. Hemodialysis machines and monitors. In Replacement of renal function by dialysis 4th edition, Jacobs, C., Kjellstrand CM, Koch KM et al. eds. Dordrecht, Kluwer. Academic Publishers, 1996. pp. 45-8.
5. Genain C, Tellier P, Syrota Act al. Infinite dilution conductometry of plasma and urine. Correlation with osmolality, *Clin, Chimica. Acta.* 1978;88: 177-82.
6. Jahrig K, Bogun KR, Grimmer J. Conductometry in determining measurements of urine electrolyte concentration. *Urologie (A)*, 1977; 16:204-7.