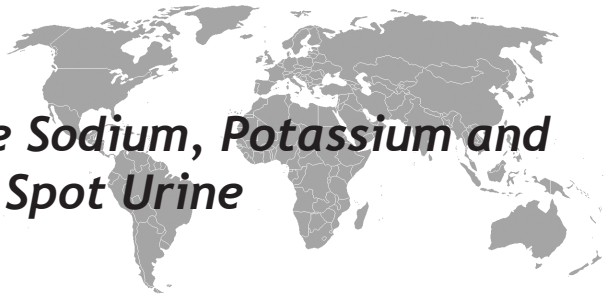

Correlation of 24-Hour Urine Sodium, Potassium and Calcium Measurements with Spot Urine

Pinar Sonat Kara[1], Reha Erkoc[2], Yasemin Usul Soyoral[3], Huseyin Begenik[3], Mehmet Naci Aldemir[4]

ABSTRACT

In this study, we analyzed the correlation of sodium(Na), potassium(K) and calcium(Ca) amounts with spot urine(SU) and 24-hour urine(24-HU) collected as 8-hour portions. 21 hypertensive patients and 21 normotensive individuals were enrolled in the study. Na, K and Ca were studied in three sequential 8-hour urine samples and with the sum of three, 24-HU samples of the cases. Sodium/creatinine, potassium/creatinine, and calcium/creatinine were studied in fasting SU and serum Na, K and creatinine were studied. A significant correlation was found between the SU sodium/creatinine ratio and the Na amount in each 8-hour urine collections, and the Na amount in the 24-hour urine in hypertensive patients, the control group, and when all patients were evaluated together. When all group were evaluated together for Ca, a significant correlation was determined between the SU calcium/creatinine ratio and the Ca amount in all three 8-hour urine collections. The Na amount in the 24-HU may be estimated both with the SU Na/creatinine ratio and the 8-hour urine collection; SU does not have clinical significance for potassium. However, it may be estimated with 8-hour urine collections; SU may help roughly for calcium, and the collected urine gives higher correlation coefficients.

Key words: *Electrolyte excretion, 24-hour urine, spot urine*

24 Saatlik İdrar Sodyum, Potasyum ve Kalsiyum Ölçümlerinin Spot İdrar ile Karşılaştırılması

ÖZET

Bu çalışmada spot idrarda sodyum, potasyum ve kalsiyum miktarı ile 24 saatlik idrar miktarlarının korelasyonunu araştırdık. Çalışmaya 21 hipertansif hasta ve kontrol grubu olarak 21 normotansif birey alındı. Olguların ardışık üç 8 saatlik porsiyon idrarında Na, K, Ca çalışıldı. Ayrıca 8'er saatlik üç porsiyon idrar toplamanın ardından sabah aç iken alınan spot idrarda sodyum/kreatinin, potasyum/kreatinin, kalsiyum/kreatinin ve serumda da sodyum, potasyum, kreatinin çalışıldı. Sekizer saatlik biriktirilmiş idrarlar ve spot idrar ile 24 saatlik idrardaki Na miktarının korelasyon analizinde; spot idrar, birinci ve üçüncü 8 saatlik porsiyon idrar sodyum/kreatinin oranı ile 24 saatlik idrarda ölçülen sodyum miktarı arasında anlamlı bir korelasyon saptandı. Kontrol grubu ve hipertansiyon grubu birlikte değerlendirildiğinde, 24 saatlik sodyum miktarı ile spot idrar sodyum/kreatinin oranı ve birinci, ikinci ve üçüncü 8 saatlik biriktirilmiş idrardaki sodyum atılımı arasında anlamlı korelasyon mevcuttu. Kalsiyum açısından tüm gruplar birlikte değerlendirildiğinde spot idrar kalsiyum /kretainin oranı ile her üç sekizer saatlik biriktirilmiş idrardaki kalsiyum miktarı arasında anlamlı korelasyon saptandı. Sabah alınan spot idrar örneğinde sodyum/kreatinin ve sekizer saatlik biriktirilmiş idrardaki sodyum miktarı ile 24 saatlik idrardaki sodyum miktarı tahmin edilebilir .Spot idrardaki potasyum miktarının miktarının klinik anlamı yoktur. Spot idrardaki kalsiyum miktarı kabaca günlük kalsiyum atılımını gösterir.

Anahtar kelimeler: *Elektrolit salınımı, 24 saatlik idrar, spot idrar*

[1]*Bingol State Hospital, Department of Internal Medicine, Bingol,* [2]*Bezmi Alem Vakif University, Faculty of Medicine, Department of Nephrology, Istanbul,* [3]*Yuzuncu Yil University, Faculty of Medicine, Department of Nephrology, Van,* [4]*Yuzuncu Yil University, Faculty of Medicine, Department of Internal Medicine, Van, Turkey*

Correspondence: *Pinar Sonat Kara, MD*
Bingol State Hospital, Department of Internal Medicine, Bingol, TURKEY
Telephone: +90 426 213 45 08
Fax numbers: +90 426 213 10 43
E-mail: sonatmert2004@yahoo.com

Received: 24.01.2012, Accepted: 28.09.2012

INTRODUCTION

High sodium intake is a well-known risk factor for hypertension and cardiovascular disease (1,2). Sodium excretion in the 24-hour urine is an important parameter as it indicates the daily salt consumption (3,4). Potassium is an important mineral for the nervous system and cardiac rhythm. Potassium excretion in the 24-hour urine indicates the dietary potassium intake (5,6). Calcium excretion in the 24-hour urine reflects the dietary calcium intake, calcium absorption, serum calcium and calcium loss from the skeletal system, and is important for studying hypercalciuria (7). Generally, 24-h urine collection is considered to be the most reliable method to evaluate these intakes. However, this method poses a considerable burden on the subjects and it is difficult to collect complete and accurate 24-h urine samples (8–10). This method may not be practical in clinical practice or in large-scale epidemiological surveys. The protein/creatinine ratio in spot urine enables the prediction of the protein amount excreted in the 24-h urine by making protein excretion independent from dilution of the urine (11). Similarly, in this study, we studied whether the 24-h urine excretion of these electrolytes could be predicted or not by using the ratio of sodium, potassium and calcium to creatinine in the spot urine, which was more practical.

MATERIALS AND METHODS

Twenty-one hypertensive patients (16 females, 5 males, mean age: 55.8 ±8.4 years), and 21 normotensive healthy individuals (15 females, 6 males; mean age: 49.3 ± 5.4 years) were enrolled in the study. This study was conducted according to the ethical principles of the Declaration of Helsinki. Approval for the study was obtained from the Ethics Committee of Yuzuncu Yıl University Medical Faculty. All patients provided written informed consent upon enrollment. The patients were informed about the purpose and the content of the study and were included in the study after consents were obtained. Those who had findings suggestive of secondary hypertension or another systemic disease according to the medical history and physical examination and in whom a pathology was detected in the routine biochemical and hematological analyses, were excluded from the study. A blood pressure of above 140/90 mmHg on admission was accepted as hypertension according to the JNC 7 criteria.

Sodium, potassium and calcium were studied in three sequential 8-h urine collections obtained following the first urination into the toilet at 08.00. Furthermore, the sodium/creatinine, potassium/creatinine, and calcium/creatinine ratios were studied in the first spot urine obtained during the fasting period following the 24-h urine. Na, K, and Ca excretions were calculated in the 8-h urines of the cases included in the study. The 24-h values were measured with the sum of these three.

The correlation of Na, K, and Ca excretion in the 24-h urine with three portions of urine collected for 8 hours and with the spot urine was studied. The first part (Na-K-Ca)1 was collected between 08–16 hours, the second part (Na-K-Ca)2 was colected between 16–24 hours, and the third part (Na-K-Ca)3 was collected between 24–08 hours. The time intervals were written on the bottles and given to the patients in order to avoid confusion. The 24-hour and the spot urine samples were analyzed with the enzymatic colorimetric method using the Integra 800 device.

Statistical analysis: The obtained data were statistically analyzed using the SPSS 15.0 program. The Student's t test was used to determine the difference between patient and the control groups in terms of the studied parameters; the Pearson correlation analysis was used to determine the relationship between the parameters of the patient and the control groups. The results were recorded as mean±standard deviation. A p level of <0.05 was accepted as statistically significant.

RESULTS

Sodium: When the hypertensive patients and the control group were compared, no significant difference was found between the Na amount in the 8-hour urine collection (Na1, Na2,Na3), the spot urine Na/Cr ratio and the and 24-hour excretion (Table 1). Sodium chloride intake was found as 10.8 ± 3.98 gr/day in the hypertension group and 12.5 ± 6.27 gr/day in the control group.

In the patient group, a significant correlation was detected between the spot urine sodium/creatinine, the Na3 urine ($r=0.702$, $p<0.01$) and the 24-h sodium excretion ($r=0.581$, $p<0.01$). A significant correlation was also found between the 24-h sodium and Na1, Na2, Na3 ($r=0.680$ ($p<0.01$), $r=0.605$ ($p<0.01$), $r=0.783$ ($p<0.01$), respectively). In the control group, a significant correlation was found between the spot urine sodium/

Table 1. *Sodium excretion in the 8-hour urine collection, in the 24-hour urine and the spot urine in the hypertension and the control groups*

	HT patients	*Controls*	*p value*
Na1(mmol)	*59.11 ± 28.62*	*82.56 ± 63.79*	*0.132*
Na2(mmol)	*61.36 ± 27.39*	*69.85 ± 33.94*	*0.378*
Na3(mmol)	*63.16 ± 40.37*	*60.11 ± 35.88*	*0.797*
Spot urine Na/Cr	*3.67 ± 2.56*	*4.05 ± 2.69*	*0.642*
24hNa(mmol)	*183.63 ± 67.63*	*212.52 ± 106.67*	*0.301*

creatinine ratio and Na1, Na3 and sodium excretion in the 24-hour urine (r =0.882 (p<0.01), r=0.541 (p<0.05), r=0.814 (p<0.01), respectively). There was also a significant correlation between the 24-hour sodium excretion and Na1, Na2, Na3 (r=0.911 (p<0.01), r=0.592 (p<0.01), r=0.793 (p<0.01), respectively). In the evaluation of all urine samples, there was a significant correlation between the spot urine sodium/creatinine and Na1, Na3 and 24-hour urine sodium (r =0.651 (p<0.01), r=0.617 (p<0.01), r = 0.713 (p<0.01), respectively). Furthermore, a significant correlation was found between the 24-hour sodium excretion and Na1, Na2, Na3 (r=0.854 (p<0.01), r=0.602 (p<0.01), r=0.741 (p<0.01),respectively)(Table 2). In this way, we found a linear regression equality as the 24-hour-Na excretion (mmol)=103.42+56.39xNa/Cr (mmol/L-mg/dl) to calculate 24-h Na excretion from spot urine Na/Cr (R2 = 0.51) (Figure 1).

Potassium: When the hypertensive patients and the control group were compared, no significant difference was found between the K amount in the 8-hour urine collection (K1, K2, K3), spot urine K/Cr and 24-hour K excretion (Table 3). In the patient group, no significant correlation was found between the spot urine potassium/creatinine and the K1,K2,K3 and 24-hour urine potassium excretion. However, there was a significant correlation between the 24-hour urine potassium excretion and K1,K2,K3 (r =0.674 (p<0.01), r =0.834 (p<0.01), r =0.459 (p<0.05), respectively). In control group, the correlation coefficient between the spot urine potassium/creatinine and K3 was low, but significant (r=0.477, p<0.05). There was also a positive correlation between the 24-hour urine potassium excretion and K1 and K3 (r =0.908 (p<0.01), r =0.772 (p<0.01), respectively). In the assessment of all urine samples, a significant correlation was found, although low, between the spot urine potassium/creatinine and K3 (r=0.315, p<0.05) and 24-hour potassium excretion (r=0.315, p<0.05). There was a significant correlation between the 24-hour urine potassium excretion and K1, K2 and K3 with higher correlation coefficients (r =0.828 (p<0.01), r = 0.570 (p<0.01), r =0.608 (p<0.05), respectively).The correlation analysis

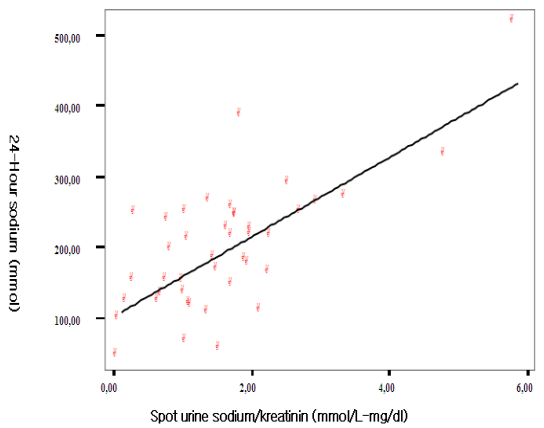

Figure 1. *The 24 hours Na and spot Na/creatinin ratio in all cases*

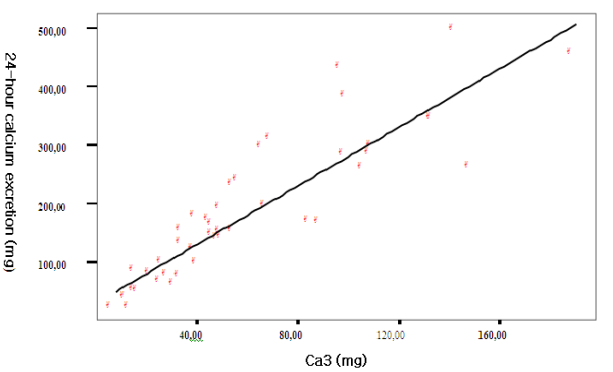

Figure 2. *24-hour Ca and Ca3 for all urine samples*

***Table 2**. Correlation analysis between the sodium parameters in all cases*

	Spot Na/Cr	Na1	Na2	Na3
Na1	0.651**			
Na2	0.253	0.306*		
Na3	0.617**	0.443**	0.202	
24hNa	0.713**	0.854**	0.602**	0.741**

*:p<0.05; **: p<0.01

***Table 3**. Potassium excretion in the 8-hour urine collection, in the 24-hour urine and the spot urine in the hypertension and the control groups.*

	HT patients	Controls	p value
K1 (mmol)	19.03±7.27	23.12±15.86	0.290
K2 (mmol)	15.90±9.00	15.00±7.41	0.726
K3 (mmol)	14.46±5.63	11.82±5.47	0.132
Spot K/Cr	2.69±1.53	2.85±1.08	0.680
24hK(mmol)	49.39±15.0	49.94±21.52	0.924

between the calcium values in the all the cases have been showed in the table 4.

Calcium: In the patient and the control groups, Ca1,Ca2,Ca3, spot urine Ca/Cr and 24-hour Ca values have been presented in table 5. A significant difference was detected between the 8-hour urine calcium (Ca1) excretion of hypertensive patients and the control group ($p<0.05$). There was a significant correlation between the spot urine calcium/creatinine ratios of the patients and Ca1,Ca2,Ca3 and 24-hour calcium excretion ($r=0.514$ ($p<0.05$), $r=0.471$ ($p<0.05$), $r=0.519$ ($p<0.05$), $r=0.537$ ($p<0.05$), respectively). Furthermore, a significant correlation was found between the 24-hour urinary Ca excretion and Ca1, Ca2, Ca3 with higher correlation coefficients ($r=0.845$ ($p<0.01$), $r=0.949$ ($p<0.01$), $r=0.946$ ($p<0.01$), respectively). There was a significant correlation between the spot urine calcium/creatinine ratio of the control group and Ca1 ($r=0.714$, $p<0.01$) and 24-hour calcium excretion ($r=0.499$, $p<0.05$). Moreover, a significant correlation was found between the 24-hour calcium excretion of the control group and Ca1, Ca2, Ca3 ($r=0.862$ ($p<0.01$), $r=0.628$ ($p<0.01$), $r=0.808$ ($p<0.01$), respectively). In the analysis of all urine samples, a significant correlation was found between the spot urine calcium/creatinine and Ca1, Ca3 and 24-h calcium excretion ($r=0.572$ ($p<0.01$), $r=0.447$ ($p<0.01$), $r=0.521$ ($p<0.01$), respectively) (table 6). Furthermore, there was a significant correlation between the 24-hour calcium excretion and Ca1, Ca2, Ca3 ($r=0.775$ ($p<0.01$), $r=0.816$ ($p<0.01$), $r=0.880$ ($p<0.01$), respectively). Thus, a linear regression equality was found as 24-hour Ca excretion(mg)=32.01+2.5xCa3 (mg) in calculating the 24-hour calcium excretion using Ca3 ($R2 = 0.78$)(Figure 2).

***Table 4**. Correlation analysis between the K parameters in all cases*

	Spot K/Cr	K1	K2	K3
K1	0.196			
K2	0.192	0.111		
K3	0.315*	0.338*	0.162	
24hK	0.315*	0.828**	0.570**	0.608**

*:p<0.05; **: p<0.01

DISCUSSION

Although the recommended daily salt amount for healthy life is 6 gr, in the SALTURK study carried out on 1767 subjects regarding the salt consumption habit and hypertension in Turkey, the mean salt consumption amount was found as 18 gr (4). In our study, the sodium chloride intake was 10.8 ± 3.98 gr/day in the hypertension group, and 12.5 ±6.27 gr/day in the control group. According to the formula we have found, the sodium/creatinine ratio should be 0.8 in the spot urine for a daily excretion of 150 mmol sodium ($R2 = 0.51$). This is equal to 8.8 gr/day sodium chloride intake. In the study of Mann et al.(12) in the correlation analysis of 24-hour Na excretion and Na/creatinine ratio in the spot urine

***Table 5**. Calcium excretion in the 8-hour and the 24-hour urine in the hypertension and the control groups and the mean values of spot urine calcium/creatinine (Ca/Cr) ratios.*

	HT patients	Controls	p value
Ca1 (mg)	47.49±30.99	80.74±66.41	0.044
Ca2(mg)	62.10±60.62	58.91±37.76	0.839
Ca3(mg)	62.39±47.16	61.13±37.53	0.924
Spot (Ca/Cr) (mg/dl-mg/dl)	0.09±0.06	0.10±0.05	0.808
24hCa(mg)	171.98±128.34	200.78±111.26	0.442

***Table 6**. Correlation analysis between the Ca parameters in all cases.*

	Spot Ca/Cr	*Ca1*	*Ca2*	*Ca3*
Ca1	*0.572***			
Ca2	*0.255*	*0.336**		
Ca3	*0.447***	*0.523***	*0.700***	
24hCa	*0.521***	*0.775***	*0.816***	*0.880***

**:p<0.05; **: p<0.01*

samples obtained when the patients were fasting in the morning at the beginning (AM), middle (PM) and just after urine collection, it was found to be correlated only with PM sample (late afternoon/early evening) (r=0.86, p<0,01). In another study of Mann et al.(13) the spot urine, the Na/creatinine ratio in the PM sample and the 24-hour Na excretion were correlated. In the study of Tsai et al.(14) the Na excretion in the 9-hour night urine collection was correlated with the 24-hour urine (r=0,78,p<0,01,) and the Na excretion in the spot urine was not correlated.

In this study, we found a significant correlation between the three portions of the 8-hour urine and the spot urine and the 24-hour Na amount in the hypertension and the control groups. When we evaluated all the cases together, we detected that the correlation coefficient between the 24-h Na excretion and Na1 (r=0.854) was higher than the correlation coefficient between Na2 (r=0.602) and Na3 (r=0.741). Hence, Na1 (between 08–16 hours) better reflects the 24-hour Na excretion, but the Na3 urine that is collected at night is more practical. Spot urine also reflects the 24-hour Na excretion, but as understood from the distribution figure, this correlation may lead to errors in routine use, it may be used as a screening test and for detection of excessive salt consumption by knowing this limitation. In our study, in the evaluation of all urine samples, the correlation coefficient between the spot urine potassium/creatinine and K3 (r=0.315, p<0.05) and the 24-hour potassium excretion (r=0.315, p<0.05) was found to be significant, but the r is very low. The correlation coefficient between potassium excretion in the urine collected between 08–16 hours (K1) and in the 24-hour urine was found to be higher (r=0,828, p=0.01). However, as patients collect urine easier at night, we may conclude that K3 urine is more practical, despite lower correlation.

In our study, in the hypertension and the control groups and when all the urine samples were analyzed, a significant correlation was detected between the calcium excretion in all three 8-hour urine collections and 24-h urine collections. It was seen that collecting three portions of 8-hour urine collection reflected the 24-hour calcium excretion, but the Ca excretion in the urine collected at night (Ca3) provided a better idea about the calcium excretion in the 24-hour urine. According to our formula, the spot urine calcium/creatinine ratio (mg/dl-mg/dl) should be 0.19 for 300 mg daily calcium excretion (R2 = 0.27). In order to calculate the 24-hour calcium excretion using Ca3, we found a linear regression equality as 24-hour Ca excretion (mg)=32.01+2.5xCa3 (mg) (R2 = 0.78). In the study of Gokce et al.(15) a significant corelation was found between the 24-hour calcium excretion and the spot urine calcium/creatinine (r=0.946,p<0.01). In our study, a significant correlation was detected between the spot urine calcium/creatinine ratio and the 24-hour calcium excretion, although the correlation coefficient was low (r=0.521). Hong et al.(16) could not find a correlation between the 24-hour urinary Na excretion and early morning (AM) spot urine Na excretion. They found a significant but low correlation with K (r=0.39). A significant correlation was found in terms of calcium excretion (r=0.669, p=0.01). In the study of Illich et al.(17) carried out on 143 healthy individuals, although there was a positive correlation between Ca, Na, and K excretion in the spot urine given just after the 24-hour urine collection and the 24-hour excretions (r=0.603, 0.452, 0.396 respectively), the significance and the need for 24-hour urine collection for evaluation of the electrolyte excretion was emphasized. Tanaka et al.(10) stated that although the formulas found for evalauting the total mean values of 24-hour sodium and potassium excretion using spot urine samples were not sufficient for estimating the individual sodium and potassium excretion, they were beneficial for estimating the mean values of the population. Kawasaki et al.(9) stated that the formulas they found for estimating the spot urine and the 24-hour sodium and potassium excretion, were sufficient for estimating the individual sodium and potassium excretion. In our study, we consider that the formula found for sodium is more practical for outpatient clinic use. According to our formula, the spot urine sodium/creatinine ratio (mmol/L-mg/dl) should be 0.8 for 150 mmol daily sodium excretion (R2=0.51). The small number of cases is an important limitation of our study. In conclusion, the 24-hour urine Na amount may be predicted, either with

the spot urine Na/creatinine ratio, or with the 8-hour urine collection. Spot urine is not of clinical importance for potassium; however, it may be estimated using the collected 8-hour urine samples. For calcium, spot urine may only give a rough idea, and collected urine samples give higher correlation coefficients.

REFERENCES

1. *Law MR. Epidemiologic evidence on salt and blood pressure. Am J Hypertens 1997;10:42-5.*
2. *Dickinson HO, Mason JM, Nicolson DJ, et al. Lifestyle interventions to reduce raised blood pressure: a systematic review of randomized controlled trials. J Hypertens 2006; 24: 215-33.*
3. *Dyer AR, Shipley M, Elliott P. Urinary electrolyte excretion in 24 hours and blood pressure in the INTERSALT Study. I. Estimates of reliability. The INTERSALT Cooperative Research Group. Am J Epidemiol 1994;139:927-39.*
4. *Erdem Y, Arici M, Altun B, et al. The relationship between hypertension and salt intake in Turkish population: SALTURK study. Blood Press 2010;19:313-8.*
5. *Geleijnse JM, Witteman JC, den Breeijen JH, et al. Dietary electrolyte intake and blood pressure in older subjects: the Rotterdam Study. J Hypertens 1996;14:737-41.*
6. *Ljutić D, Dodig J, Kovacić V. Arterial hypertension and diet. Lijec Vjesn 2007;129:364-6.*
7. *Coe FL, Parks JH, Asplin JR. The pathogenesis and treatment of kidney stones. N Engl J Med 1992;327:1141-52.*
8. *Dyer AR, Elliott P, Shipley M. Urinary electrolyte excretion in 24 hours and blood pressure in the INTERSALT Study. II. Estimates of electrolyte-blood pressure associations corrected for regression dilution bias. The INTERSALT Cooperative Research Group. Am J Epidemiol 1994;139:940-51.*
9. *Kawasaki T, Itoh K, Uezono K, Sasaki H. A simple method for estimating 24 H urinary sodium and potassium excretion from second morning voiding urine specimen in adults. Clin Exp Pharmacol Physiol 1993;20:7-14.*
10. *Tanaka T, Okamura T, Miura K, et al. A simple method to estimate populational 24-h urinary sodium and potassium excretion using a casual urine specimen. J Hum Hypertens 2002;16:97-103.*
11. *Tamura S, Shimizu T, Kawakatsu H, Tateishi S. Correlation between 24-hour urinary protein excretion and protein/creatinine ratio in the first voided morning urine samples. Nippon Jinzo Gakkai Shi 2004;46:26-34.*
12. *Mann SJ, Gerber LM. Estimation of 24-hour sodium excretion from spot urine samples. J Clin Hypertens (Greenwich) 2010;12:174-80.*
13. *Mann SJ, Gerber LM. Estimation of 24-h sodium excretion from a spot urine sample using chloride and creatinine dipsticks. Am J Hypertens 2010;23:743-8.*
14. *Tsai TJ, Chen YM, Hsieh BS, Chen WY. Comparison between spot urine and overnight urine in the estimation of 24-hour excretion of urine protein, sodium and kallikrein. J Formos Med Assoc 1991;90:755-9.*
15. *Gökçe C, Gökçe O, Baydinç C, et al. Use of random urine samples to estimate total urinary calcium and phosphate excretion. Arch Intern Med 1991;151:1587-8.*
16. *Hong YH, Dublin N, Razack AH, Mohd MA, Husain R. Twenty-four hour and spot urine metabolic evaluations: correlations versus agreements. Urology 2010;75:1294-8.*
17. *Ilich JZ, Blanusa M, Orlić ZC, Orct T, Kostial K. Comparison of calcium, magnesium, sodium, potassium, zinc, and creatinine concentration in 24-h and spot urine samples in women. Clin Chem Lab Med 2009;47:216-21.*