The Effect of Dehydration on Quantitative Tc-99m DTPA Renal Scintigraphy

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The aim of this study was to show the effects of dehydration of 12 hours on quantitative Tc-99m DTPA renal scintigraphy in order to exclude the changes of dehydration on renography. For this purpose, Tc-99m DTPA scintigraphy was performed on 20 healthy volunteers twice. While first study was on standart hydration state, second study was performed with dehydration of 12 hours after two days from the first study. Tmax of whole kidney [Tmax (WK)], Tmax of cortex [Tmax(c)], glomerular filtration rate (GFR), mean parenchymal transit time [MTT(p)], and mean cortical transit time [MTT(c)] were calculated from the renograms. While, there were not statistically significant differences ($p >; 0.05$) for Tmax(c), MTT(c), and GFR values there were significant differences ($p < 0.05$) for Tmax (WK) and MTT(p) values between hyration and dehydration states. This study indicates that the effects of dehydration such as delayed uptake and prolonged transit may not be observed by using Tmax(c) and MTT(c) values.

Key words : Tc-99m DTPA, Radionuclide renography, Dehydration

Bu çalışmanın amacı, dehidrasyonun renografideki etkilerini dışlayabilmek amacıyla, 12 saatlik dehidrasyonun kantitatif Tc-99m DTPA böbrek sintigrafisine etkilerini belirlemektir. Bu amaçla, 20 sağlıklı gönüllüye iki kez Tc-99m DTPA sintigrafisi uygulanmıştır. İlk çalışma standart hidrasyon durumunda uygulanmışken, ikinci çalışma ilk çalışmadan iki gün sonra ve 12 saatlik dehidrasyon durumunda gerçekleştirilmiştir. Tüm böbrek Tmax [Tmax (WK)], kortikal Tmax [Tmax (c)], glomerüler filtrasyon hızı (GFR), ortalama parenkimal geçiş zamanı [MTT(c) ve GFR değerleri istatistiksel anlamlı farklılık göstermezken ($p > 0.05$), Tmax (WK) ve MTT(p) değerleri anlamlı olarak farklı bulunmuştur ($p < 0.05$). Bu çalışma, gecikmiş uptake ve uzamış transit gibi dehidrasyon etkilerinin Tmax (c) ve MTT (c) parametrelerinin kullanılarak dışlanabileceğini göstermiştir.

Anahtar Kelimeler : Tc-99m DTPA, Radyonüklid renografi, dehidrasyon

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INTRODUCTION

Hydration of the patients before radionuclide renography studies is an important factor especially in comparative studies such as renovascular hypertension (1). Dehydration causes decreased urine flow rate. Wedeen and Blaufox (2) reported the effect of urine flow rate on the renogram pattern. The second and third phase of the renogram are prolonged when the urine flow rate is low. In addition these phases may demonstrate 'steps' as a result of periodic peristaltic removel of small quantities of urine containing high concentrations of radioactivity. Since steps in well-hydrated patients can be a sign of urinary tract disease, it is important to hydrate the patient prior to the test in order to prevent misinterpretation (2, 3). In addition to these reasons for hydrating the patient, drinking large quantities results in a decrease in bladder radiation dose (4, 5).

In this study, we aimed to show the effects of dehydration of 12 hours on quantitative Tc-99m DTPA renal scintigraphy, in order to exclude the changes of dehydration on renography.

MATERIALS AND METHODS

Twenty healthy volunteers were included in this study. After bolus injection of 370 MBq Tc-99M DTPA, a 20 minute continuous posterior study in the supine position was acquired, including 60 frames in 64x64 matrix of 20 seconds for each framewith Toshiba GCA 602 A digital gamma camera. All scintigrams were performed twice (firstly in standart hydration with 8-10 ml. kg^{-1} fluid orally before 1 hour from the study and after two days with a dehydration of 12 hours) for each volunteers. Following parameters were calculated:

1. Tmax of whole kidney [Tmax(WK)]: The time to peak on the whole kidney renogram.
2. Tmax of cortex [Tmax(c)]: The time to peak on the cortical renogram.
3. Glomeruler Filitration Rate (GFR): Calculated by modified Gates Method (6).
4. Mean Parenchymal Transit Time [MTT(p)]: ROI was drawn from the whole parenchyma containing both of cortical nephrons (CNs), juxtamedullary nephrons (JMNs), and collecting duct by only excluding pelvis (7).
5. Mean Cortical Transit Time [MTT(c)]: ROI was drawn from the outer of cortex contains primarily CNs rather than JMNs (7).

MTT(p) and MTT(c) values were calculated by deconvolution analysis. In this calculation input function was selected on cardiac region (8). Wilcoxon test was used for statistical analysis and results were shown as mean ± SD.

RESULTS

Table 1 showed Tmax (WK) and Tmax(c) values in hydration and dehydration. While Tmax(WK) was 7.32 ± 0.98 min on the left kidney, and 9.58 ± 1.35 min on the right kidney in dehydration; these values were 3.55 ± 0.73 min and 4.23 ± 0.61 min in hydration, respectively. The differences between these values were statistically significant ($p < 0.05$). On the other hand there was not statistically significant differences for Tmax(c) values between hydration and dehydration ($p > 0.05$). In dehydration Tmax(c) value was 3.5 0.91 min on the left kidney and 3.90 ± 0.74 min on the right kidney; in hydration 3.43 ± 0.80 min and 3.77 ± 0.63 min, respectively (Fig. 1).

Table 1. Tmax(WK) and Tmax(c) values in dehydration and hydration.

	Tmax(WK) min		Tmax(c) min	
	Left	Right	Left	Right
Dehydration	7.32±0.98*	9.58±1.35**	3.50±0.91•	3.90±0.74••
Hydration	3.55±0.732*	4.23±0.61**	3.43±0.80•	3.77 ± 0.63••

* $p < 0.05$, ** $p < 0.05$, • $p > 0.05$, •• $p > 0.05$

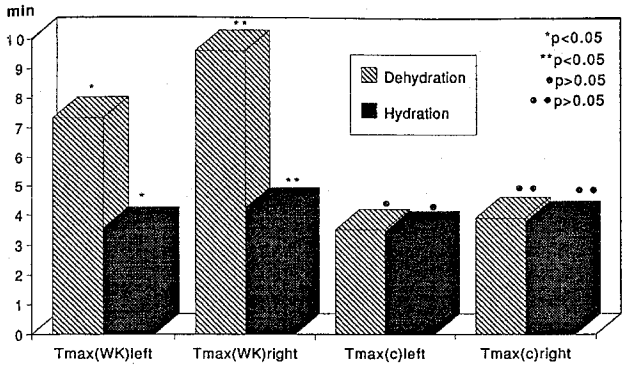

Fig. 1. The differences in Tmax(WK) values between hydration and dehydration were statistically significant but there was not a significant difference in Tmax(c) values.

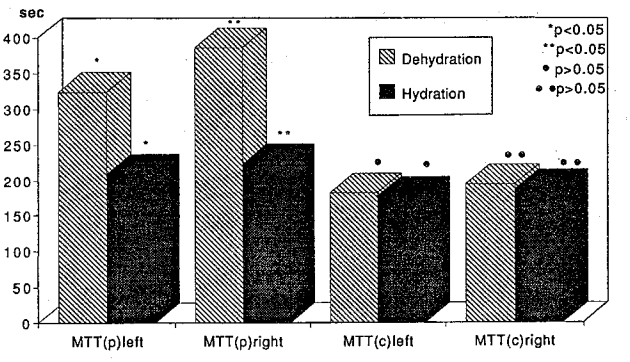

Fig. 2. The differences in MTT(p) values between hydration and dehydration were statistically significant but there was not a significant difference in Tmax(c) value.

GFR did not show statistically significant difference between hydration and dehydration, either ($p > 0.05$) (Table 2). While GFR was 102 ± 25.31 ml. min^{-1} in hydration, it was 97.35 ± 24.4 ml. min^{-1} in dehydration.

Table 2. Total GFR values in dehydration and hydration

	Total GFR ($ml \cdot min^{-1}$)
Dehydration	97.35 ± 24.4*
Hydration	102 ± 25.31*

* $p > 0.05$

MTT(p) and MTT(c) values were shown in Table 3. While MTT(p) was 324 ± 17 sec on the left kidney, and 386 ± 26 sec on the right kidney in dehydration; 210 ± 14 sec and 224 ± 18 sec , in hydration, respectively. Altough statistically significant differences were present between these values ($p < 0.05$), there were not for MTT(c) values between hydration and dehydration ($p > 0.05$) (Fig. 3). While MTT(c) was 183 ± 18 sec on the left kidney and 195 ± 22 sec on the right kidney in dehydration; 178 ± 12 sec and 188 ± 19 sec in hydration, respectively (Fig. 2).

Table 3. MTT(p) and MTT(c) values in dehydration and hydration.

	MTT(p) sec		MTT(c) sec	
	Left	Right	Left	Right
Dehydration	324±17*	386±26**	183±18•	195±22••
Hydration	210±14*	224±18**	178±12•	188 ±19••

* $p < 0.05$, ** $p < 0.05$, • $p > 0.05$, •• $p > 0.05$

DISCUSSION

It is suggested that patients should be normally hydrated with a urine flow rate between 1.5 and 7 ml. min-1 (3). For this purpose the patient must drink fluid based on body weight (8 ml. kg-1) 1 hour before the test(9). In this study, we also hydrated patients with 8-10 ml.kg-1 water 1 h before the study for state of hydration. It is significant that the normal renogram is quite sensitive to the effects of hydration and dehydration causes delayed uptake, prolonged transit and delayed excretion due to increased water reabsorption (7). It is reported that the time to peak depends on the state of hydration of the patient (10). In our study, while Tmax(WK) and mTT(p) values were significantly prolonged in dehydration compared to hydration; Tmax(c) and MTT(c) values were not showed significantly differences between in states of dehydration and hydration. Prolonged Tmax(WK) in dehydration compared to hydration depends on stasis of radioactivity in medullary system and pelvis due to the decreased urine flow rate. In contrast Tmax(c) value did not show statistically significant difference between hydration and dehydration states, since medullary system and pelvis were excluded on the ROI.

Transit time of a radiopharmaceutic extracted by the kidney depends on the length of the nephron (11, 12). Cortical nephrons (CNs) have short loops of Henle, whereas Juxtamedullar nephrons (JMNs) have long loops. In our study, primarily cortical

nephrons rather than JMNs were included on the ROI's in the calculation of MTT(c). Since CNs have shorter loops of Henle than JMNs, MTT(c) can not be affected by 12 hours of dehydration.

On the other hand MTT(p) was prolonged in dehydration compared to hydration because of the stasis of activity in the collecting duct and JMNs which have longer loops of Henle. In another term, decreased urine flow rate occured by 12 hours of dehydration may not affect the MTT(c) since CNs have shorter loops of Henle than JMN.

In our study, GFR calculated by modified Gates Method did not show statistically significant difference between hydration and dehydration. It is known that dehydration stimulates renin secretion from juxtaglomerular apparatus. The resulting renin release causes production of angiotensinII which predominantly occured vasoconstriction on efferent arteriol, resulting in restored filtration fraction and GFR, although decreased extracellular fluid volume due to dehydration (13). It was thought that renin-angiotensin system can be a responsible factor for restoring GFR in dehydration of 12 h in this study.

In summary, the findings of our study suggest that although hydration is very important and necessary before radionuclide renography studies in order to obtain phisiological urine flow rate and decreased in bladder radiation dose, the effect of dehydration can be excluded using Tmax(c) and MTT(c) calculated from the outer cortex which has primarily CNs rather than JMNs.

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