RESEARCH ARTICLE

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Comparisons of Different Preparation Methods in Computed Tomography Urography

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Objective: Computed Tomography Urography (CTU) is an imaging method used to assess the kidneys, ureters, and bladder in the excretory phase by computed tomography (CT) with intravenous contrast media (IVCM). Our aim is to compare the five different methods performed for patient preparation prior to CTU, and to demonstrate their superiorities and disadvantages compared to each other.

Materials and Methods: A total of 100 patients who underwent CTU scans with an indication as a result of their examinations were included in our study. These cases were randomly divided into 5 groups of 20. Water was applied to the first group. Saline was administered to the second group. In the third group, 0.1 mg/kg furosemide was administered intravenously following a 250 mL saline. Intravenous furosemide was administered to the fourth group. Intravenous furosemide was administered to the fifth group after they received water. Ureters were compared with each other according to the degree of opacification in proximal, medial, and distal segments in standard CTU.

Results: By comparing the groups in pairs; there was a significant difference between Group II and the other four groups for the proximal ureter segment, and between Group II and Group III and IV for the medial and distal ureter segments (P<0.05).

Conclusion: We believe that intravenous saline didn't increase ureter opacification compared to the other groups due to different patient populations and hydration conditions, instead saline increased ureter contractions and homogeneous diuresis related to furosemide.

Key words: *Tomography, urography, patient, furosemide, ureter*

Bilgisayarlı Tomografi Ürografisinde Farklı Hazırlık Yöntemlerinin Karşılaştırılması

Amaç: Bilgisayarlı Tomografi Ürografi (BTÜ), intravenöz kontrast madde (İVKM) kullanılarak ekskretuar fazda böbrekler, üreterler ve mesaneyi değerlendirmek için kullanılan bir görüntüleme yöntemidir. Amacımız BTÜ öncesi hasta hazırlığı için uygulanan beş farklı yöntemi kıyaslayarak üstünlüklerini ve dezavantajlarını ortaya koymaktır.

Gereç ve Yöntem: Çalışmada muayeneleri sonucunda endikasyonla BTÜ taraması yapılan toplam 100 hasta dahil edildi. Olgular rastlantısal olarak 20'şerli 5 gruba ayrıldı. Birinci gruba su içirildi. İkinci gruba salin infüzyonu yapıldı. Üçüncü gruba salin infüzyonu sonrası furosemid intravenöz olarak uygulandı. Dördüncü gruba intravenöz furosemid verildi. Beşinci gruba su içirilmesi sonrasında intravenöz furosemid yapıldı. Standart BTÜ ile üreterler proksimal, orta ve distal segmentlerde opasifikasyon derecelerine göre birbirleri ile karşılaştırıldı.

Bulgular: Grupların ikili olarak karşılaştırılmasında; proksimal üreter segmenti için Grup II ile diğer dört grup arasında, medial ve distal üreter segmentleri için Grup II ile Grup III ve IV arasında anlamlı farklılık saptandı (P<0.05).

Sonuç: İntravenöz salinin farklı hasta popülasyonu ve hidrasyon durumu nedeniyle diğer gruplara göre üreter opasifikasyonunu artırmadığını, salinin üreterlerin peristaltik kasılmalarını ve furosemidin sağladığı homojen diürezi arttırdığını düşünüyoruz.

Anahtar Kelimeler: *Tomografi, ürografi, hasta, furosemid, üreter*

Introduction

Computed Tomography Urography (CTU) is the imaging method preferred in the imaging of the pelvicalyceal system, ureters, and bladder (1). It not only evaluates the urinary tract in detail, but also enables the comprehensive evaluation of neighboring structures, abdomen, and pelvis. Standard imaging protocol consists of three phases; non-contrast (unenhanced), nephrographic, and excretory (2). The primary purpose of the excretory phase is to make the collecting duct system completely opaque (3). CTU replaced other methods, especially Intravenous Urogram (IVU). Indications can be counted as the staging and follow-up of hematuria, urothelial malignancies in specialty patients, and evaluation of postoperative anatomic distortions, 3-dimensional imaging for trauma, complicated infections, and percutaneous nephrolithotomy (1). On the other hand of the comprehensive evaluation of the urinary system, high-dose contrast media (100-150 ml), high-dose radiation, and the need for multiple images for interpretation are its disadvantages (4). Creatinine levels of the patients must be known before the

scan. Intravenous contrast media (IVCM) should not be used in patients with a creatinine level above 1.4 mg/dL and a history of allergy to contrast media (5). It has been stated in many studies that different diuresis techniques may have positive and negative effects on imaging (6-8).

Our objective is to determine the ideal preparation method by showing the superiority and disadvantages of the methods used for patient preparation before CTU among each other.

Materials and Methods

Patients who were examined in the clinics and polyclinics of Firat University Faculty of Medicine Hospital between June 2010 and October 2011 and who were given CTU indication with the purpose of investigating the cause of hematuria, complicated urinary system infection, hydronephrosis, symptomatic urolithiasis cases who had percutaneous nephrolithotomy planned and cases with upper or lower urinary system tumor risk were included in the study. Patients with hypotension, heart failure, furosemide and sulfate allergies were excluded from the study. Patients were between the ages of 18 and 68 and the mean age was 41. Out of the 100 cases 57 (57%) were female and 43 (43%) were male. Examinations were performed in the Firat University Hospital Department of Radiodiagnostics with the use of TOSHIBA brand TSX-101A/HC Model AQUILION 64 CT Device with 120 kV, 300 mA, time 0.5 sec and 0.5 mm slice thickness. Ethics committee permission for the study was obtained from Fırat University(Date; 01.07.2010, Number; 06, Meeting Number; 06). Five different preparation methods were performed on randomly selected groups of 20 people. The first group was made to drink 1000 mL of water one hour before imaging. The second group was administered 250 mL saline (isotonic NaCl) infusion prior to IVCM injection. Third group was administered 250 mL saline infusion prior to and 0.1 mg/kg IV Furosemide after the IVCM injection. The fourth group was administered 0.1 mg/kg IV Furosemide prior to the IVCM injection. The fifth group was made to drink 1000 mL of water one hour before imaging and was administered 0.1 mg/kg IV Furosemide prior to the IVCM injection. The scans in all cases were performed in the supine position and without applying compression. 100 mL of 350 mg/mL contrast media was administered to the patients using an automatic injector into the antecubital vein at a speed of 3 mL/sec. Non-contrast, post injection nephrographic phase (100^{th} sec.), and late phase (15^{th} minute) images were acquired. In the interpretation of the images, in addition to the axial images, multiplanar reconstruction (MPR), volume rendering and maximum intensity projection (MIP) techniques were used on the workstation (Vitrea 2; Vital Images, Inc. Minneapolis, Minn, USA). The acquired axial images and the coronal 5 mm thin and thick MIP images obtained from these images were used in the examination. A radiologist blind to the preliminary diagnoses evaluated 200 ureters, without right-left separation, by dividing them into three regions as proximal, medial, and distal.

Proximal ureter segment was defined from the ureteropelvic junction to the first slice in which the iliac bone appears, medial ureter segment was defined from the iliac bone to the end of the sacroiliac joint, distal ureter segment was defined from the end of the sacroiliac joint to the entrance of the bladder and they were compared to each other according to the degree of opacification. The degree of opacification was expressed as values up of 0, 1, 2, 3, and 4. No opacification was scored as 0, opacification of less than 25% was scored as 1, opacification of 26-50% was scored as 2, opacification of 52-75% was scored as 3 and opacification of 76% or more was scored as 4.

The Anova test was used in the evaluation of the groups with each other as a whole and Tukey analysis test was used in the comparison of in which pairs of groups the significance between the groups occurred. Analyses were performed with the statistics package for social sciences (SPSS, Chicago, IL, USA) version 15.0. Ethics committee approval and informed consent from the patients were obtained prior to the beginning of the study.

Results

In our study, 200 ureters of 100 cases were examined in the excretory phase in three segments, proximal, medial, distal. In the conducted evaluation, none of the ureter segments had opacification of more than 25%. For each segment, mean values, standard deviation, minimum and maximum values were presented in Table 1.

Non- contrast phase images of the CTU revealed renal cysts in 60 (60%) cases, renal stones in 47 (47%) cases and angiomyolipoma in 12 (12%) cases. In the nephrographic phase images, contrast was detected in the septa and walls of 9 (9%) cases with renal cysts (Bosniak category III). Heterogeneous contrast existed in patients who had angiomyolipoma detected. In other cases in which we didn't detect cortical and medullary pathologies, kidney parenchyma had normal contrast. Trabeculation was detected in the bladder wall of 40 (40%) patients in the excretory phase images. In other cases, 60 (60%) bladders showed normal filling. Based on our results, we can say that we were able to evaluate renal and bladder pathologies in addition to the urinary tract in CTU.

Table 1. Data obtained for the degrees of opacification of ureter segments

Ureter Segments	Group	N	Average	SD	Min. Value	Max. Value
Proximal Segment	1	40	3.48	0.679	2	4
	2	40	3.05	0.714	2	4
	3	40	3.53	0.554	2	4
	4	40	3.58	0.501	3	4
	5	40	3.43	0.501	3	4
Middle Segment	1	40	3.40	0.810	2	4
	2	40	3.10	0.744	2	4
	3	40	3.78	0.423	3	4
	4	40	3.60	0.496	3	4
	5	40	3.45	0.504	3	4
Distal Segment	1	40	3.35	0.802	2	4
	2	40	3.13	0.607	2	4
	3	40	3.65	0.483	3	4
	4	40	3.53	0.506	3	4
	5	40	3.48	0.506	3	4

Table 2. Statistical results in comparison of groups (Tukey test P<0.05)

Groups	Comparison Group	Proximal Segment	Middle Segment	Distal Segment
Group 1	Grup 2	0.014*	0.191	0.438
	Grup 3	0.996	0.053	0.161
	Grup 4	0.944	0.593	0.679
	Grup 5	0.996	0.996	0.880
Group 2	Grup 1	0.014*	0.191	0.438
	Grup 3	0.004*	0.000*	0.001*
	Grup 4	0.001*	0.003*	0.024*
	Grup 5	0.043*	0.085	0.067
Group 3	Grup 1	0.996	0.053	0.161
	Grup 2	0.004*	0.000*	0.001*
	Grup 4	0.996	0.708	0.880
	Grup 5	0.944	0.130	0.679
Group 4	Grup 1	0.944	0.593	0.679
	Grup 2	0.001*	0.003*	0.024*
	Grup 3	0.996	0.708	0.880
	Grup 5	0.793	0.811	0.996
Group 5	Grup 1	0.996	0.996	0.880
	Grup 2	0.043*	0.085	0.067
	Grup 3	0.944	0.130	0.679
	Grup 4	0.793	0.811	0.996

*P<0.05

In the comparison of the groups with each other in pairs for the evaluation of the proximal ureter segment; a statistically significant difference was found between Groups 1, 3, 4, 5 and Group 2 (P<0.05, Table 2). There was no significant difference found between Groups 1, 3, 4, 5 when compared with each other (P>0.05 Table 2, Figure 1). Compared to the other groups the proximal ureter segment had a lower rate of opacification in Group 2 which only had saline administered. In the comparison of the the groups with each other in pairs for the evaluation of the medial ureter segment; a statistically significant difference was found between Groups 3, 4 and Group 2 (P<0.05, Table 2). There was no significant difference found in the comparison of Groups 1, 5 with Group 2 and Groups 1, 3, 4, 5 with each other (P> 0.05, Table 2, Figure 2). Compared to Groups 3 and 4, medial ureter segment had a lower rate of opacification in Group 2 which only had saline administered. In the comparison of the groups with each other in pairs for the evaluation of distal ureter segment; a statistically significant difference was detected between Groups 3, 4 (Figure 3) and Group 2 (P<0.05, Table 2). There was no significant difference detected in the comparison of Group 2 with Groups 1, 5 and the comparison of Groups 1, 3, 4, 5 with each other (P>0.05, Table 2). Compared to Groups 3 and 4, distal ureter segment had a lower rate of opacification in Group 2 which only had saline administered.

Figure 1. Coronal CTU image show of the both upper ureter segment on Grade II opacification of a case in Group V

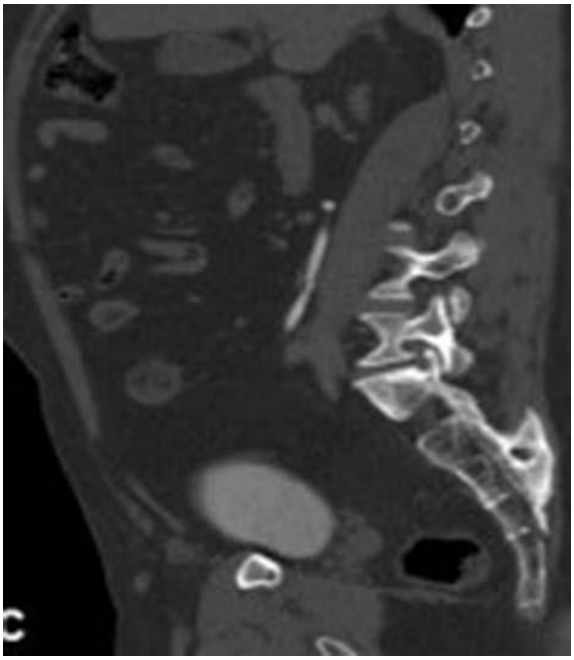

Figure 2. Sagittal CTU image Show of right middle ureter segment on Grade III opacification of a patient in Group III

Figure 3. Coronal CTU image show of right distal ureter segment on Grade IV opacification of a patient in Group IV

Discussion

CTU is an excretory urogram, which provides a reliable evaluation of the kidneys and urinary system, in which CT is used instead of conventional radiography in the imaging of the urinary system (6). Imaging in the excretory phase following IVCM in CTU doesn't mean that imaging cannot be performed without contrast. Precontrast slices are important in the evaluation of renal parenchyma (7). Imaging was performed from end to end in the non-contrast phase from the top level of the kidneys including the entirety of the bladder (9). Differentiation of urinary system stones, intralesional lipid and calcification content, malignant lesions and non-contrast hyperdense hematomas is important in this phase (1). Cortical cysts, stones and angiomyolipoma were detected in the non-contrast phase images in our study.

An unenhanced scan is initially performed from the upper poles of the kidneys to the lower edge of the symphysis pubis using 3 mm to 5 mm thick sections in the prone position. High attenuation oral contrast should be avoided, as dense contrast can make detection of ureteric calculi more difficult. This is followed by nephrographic phase (90–100 seconds after contrast administration) imaging of the kidneys, and excretory phase imaging (8–15 minutes after contrast administration) of the entire urinary tract (10). Malign lesions ureter wall thickness increase which are denser and more enhanced compared to urine are better detected in the nephrographic phase (1). Septa and wall enhancing (Bosniak Category 3) existed in some of the

cortical cysts detected in our study. Heterogeneous enhancing was detected in angiomyolipomas. Excretory phase images are necessary for the evaluation of the lumen of the collecting duct system. Different preparation techniques before CTU have been defined. The purpose of these techniques is to provide maximum distension and full opacification of the urinary tract with the excrete contrast media. It is believed that the sensitivity and specificity of lesion detection will increase when these two factors are optimized (11). There were cases in the present study which had trabeculation detected in the bladder wall in the excretory phase images.

It is difficult for the intrarenal collecting duct system and ureters to have complete opacification in one scan. There are studies using various techniques for optimal urinary tract distension and opacification. Various techniques such as imaging in prone position, abdominal compression, Valsalva maneuver, oral hydration, hydration by intravenous saline, administration of furosemide or antispasmodic agents and multiphase scans are recommended (1, 2, 9, 12-14). No consensus has yet been reached on the preparation stage (7).

Use of furosemide provides the opacification of medial and distal ureters (9, 15). Diuretics can increase medial and distal urethral distension compared to hydration alone (15). Groups which had furosemide administered (Groups 3 and 4) had better opacification in the ureters compared to the group which had IV hydration with saline (Group 2). Oral hydration with water doesn't cause an additional cost and provides distension of the collecting duct system with diuresis. However, caution should be exercised in patients with limited fluid intake. Intravenous hydration causes more distension but may stimulate the peristaltic contraction of the ureters (15).

Others have noted that the use of intravenous saline hydration yields opacification of the urinary tract in comparison with that obtained with excretory urography. Several studies have described CTU scanning protocols in western population, using different scanning-phase and contrast media injection protocols (16).

Kawamoto et al. (12) detected that drinking adequate amount of water and adequate absorption from the gastrointestinal system shows similar effects to IV hydration. In our study, we detected that the group which had oral hydration administered had better opacification in the proximal ureter segment compared to the group with IV hydration and that the two groups showed similarity in the medial and distal ureter segments.

To date, a few investigators have suggested that abdominal compression during CTU results in improved opacification of the intrarenal collecting system and ureter, which is similar to the excretory urography (16). On the other hand, Dillman et al. (11), Hage et al. (13) detected that compression doesn't cause a significant difference in urinary tract distension and opacification in CTU. Since caution must be exercised in compression techniques for cases such as acute abdominal pain, history of recent surgery and abdominal aorta aneurism, compression applications were not performed in our study.

The study conducted by Sanyal et al. (17) showed, in support of our study, that use of furosemide causes full opacification in ureters. Bellin et al. (18) detected that the use of furosemide, compared to the use of intravenous saline, forms homogenous distribution of the contrast media in the urinary tract. Lee et al. (14) separated the patients into 3 groups and performed the split bolus technique in each group by giving a different contrast percentage in each bolus. They divided the ureters into proximal, medial and distal segments. They didn't detect a significant difference between the ureter segments and between the groups in their study.

Furosemide provides continuous diuresis and homogeneous opacification of the urinary tract and causes lower attenuation values of excreted urine. Furosemide shouldn't be administered to patients who are known to be allergic to furosemide or other sulphate medications, who have systolic blood pressure below 90 mmHg, acute renal colic and urinary tract obstruction (1).

The techniques used in the preparation stage are oral and/or IV hydration administered before the scan, IV furosemide before IV contrast media, use of abdominal compression devices, inclined patient positioning (19, 20). Since the results are equal and most of these techniques are not practical or potentially harmful, oral hydration can be the simplest approach (21).

As can be understood from the conducted studies, many methods to increase the image quality, sensitivity and specificity at every stage of the CTU scan have been tried. Contradicting results were acquired.

We believe that the reason for intravenous saline not increasing ureter opacification compared to other groups was due to the difference in patient population and hydration statuses of patients, saline increasing the peristaltic contractions of ureters and the homogenous diuresis provided by furosemide.

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