Korean Journal of Pediatrics Vol. 53, No. 2, 2010
DOI : 10.3345/kjp.2010.53.222
■ Original article : Clinical study ■

The relationships between clinical variables and renal parenchymal disease in pediatric clinically suspected urinary tract infection

Jung Lim Byun, M.D., Sang Taek Lee, M.D., Sochung Chung, M.D. and Kyo Sun Kim, M.D

Department of Pediatrics, Konkuk University School of Medicine, Seoul, Korea

= Abstract =

Purpose : To evaluate the significance of clinical signs and laboratory findings as predictors of renal parenchymal lesions and vesicoureteral reflux (VUR) in childhood urinary tract infection (UTI).

Methods : From July 2005 to July 2008, 180 patients admitted with a first febrile UTI at the Pediatric Department of Konkuk University Hospital were included in this study. The following were the clinical variables: leukocytosis, elevated C-reactive protein (CRP), positive urine nitrite, positive urine culture, and fever duration both before and after treatment. We evaluated the relationships between clinical variables and dimercaptosuccinic acid (DMSA) scan and voiding cystourethrography (VCUG) results.

Results : VCUG was performed in 148 patients; of them, 37 (25.0%) had VUR: 18 (12.2%) had low-grade (I-II) VUR, and 19 (10.5%) had high-grade (III-V) VUR. Of the 95 patients who underwent DMSA scanning, 29 (30.5%) had cortical defects, of which 21 (63.6%) had VUR: 10 (30.3%), low-grade (I-II) VUR; and 11 (33.3%), high-grade VUR. Of the 57 patients who were normal on DMSA scan, 8 (14.0%) had low-grade VUR and 6 (10.5%) had high-grade VUR. The sensitivity, specificity, and positive and negative predictive values of the DMSA scan in predicting high-grade VUR were 64.7%, 69.9%, 33.3%, and 89.5%, respectively. Leukocytosis, elevated CRP, and prolonged fever (≥36 hours) after treatment were significantly correlated with the cortical defects on DMSA scans and high-grade VUR.

Conclusion : Clinical signs, including prolonged fever after treatment, elevated CRP, and leukocytosis, are positive predictors of acute pyelonephritis and high-grade VUR. **(Korean J Pediatr 2010;53:222-227)**

Key Words : Urinary tract infection, Vesicoureteral reflux, Tc-99m Dimercaptosuccinic acid, Child

Introduction

Urinary tract infection (UTI) is a common bacterial infection identified in young, febrile children[1]. UTI may be limited to the bladder (cystitis) or can also involve the renal parenchyma (pyelonephritis)[2]. The clinical presentation of UTI may be non-specific and varies depending on factors such as the age of the child and the severity of infection[3]. Accurate diagnosis based on clinical presentation and positive urine culture is often difficult, particularly in infants and children. Children with renal involvement are at risk of permanent renal damage, which may give rise to severe sequelae such as hypertension, preeclampsia and renal failure[4, 5]. Recurrent infections, renal scarring and vesicoureteral reflux (VUR) are risk factors for the development of progressive renal damage[6, 7]. Therefore, it is necessary to find a predictor of acute pyelonephritis (APN) and high grade (III-V) VUR from clinical variables and laboratory findings. Prior studies have investigated factors associated with renal scarring in children with a UTI, but their outcomes had some differences[8, 9].

The aim of this study was to evaluate the value of clinical signs, such as fever duration and leukocytosis, elevated CRP, and positive urine nitrite, for identifying children at risk of APN or high grade VUR. We designed this study to assess factors that might influence the identification of renal parenchymal lesions, including leukocytosis, CRP, urine

Received : 21 August 2009, Revised : 19 October 2009
Accepted : 2 November 2009
Address for correspondence : Kyo Sun Kim, M.D.
Department of Pediatrics, Konkuk University Hospital, Konkuk University School of Medicine, 4-12 Hwayang-dong, Gwangjin-gu, Seoul, 143-729 Korea
Tel : +82.2-2030-7557, Fax : +82.2-2030-7749
E-mail : kimkyo@kuh.ac.kr

nitrite, positive urine culture, median time of fever duration before and after treatment, and abnormalities of imaging studies in children with febrile UTI.

Materials and methods

We reviewed the medical records of 180 patients who presented with a first febrile UTI episode from July 2005 to July 2008 at the Department of Pediatrics, Konkuk University. Of these patients, 88 (48.9%) were boys and 92 (51.1%) were girls; 149 (83%) were less than five years of age; 31 (17%) were older than five years; their ages ranged from one month to 17 years old.

1. Subjects

Inclusion criteria were as follows: fever, with a temperature ≥38℃ and positive urine culture result which growth of single organism with colony counts equal to or greater than 100,000 colony-forming units per mL. Also, a urine was cultured if UTI was clinically and strongly suspected. All urine samples were immediately sent for culture. Common contaminations, including Lactobacillus species, Corynebacterium species, coagulase negative staphylococci and alpha hemolytic streptococci were excluded. Patients with a previous history of UTI, structural abnormalities such as a neurogenic bladder, posterior urethral valve, ureteroceles or a congenital disorder were excluded from this study. The study sample included 68 children with negative urine cultures who had evidence of UTIs based on predetermined criteria. The criteria included essential and supportive criteria. Three essential criteria used were (a) fever (≥ 38℃) without focus, (b) alterations in the urinary sediment (such as pyuria >10 cells/HPF, bacteriuria, hematuria, positive urine nitrite), (c) negative urine culture. Four supportive criteria used were (a) elevated CRP, (b) leukocytosis, (c) antibiotic therapy prior to hospitalization, (d) abnormalities of DMSA scan[1]. Children who fulfilled all 3 essential criteria and 2 supportive criteria were included in the study. They were considered as UTI. We decided these essential and supportive criteria in the light of the clinical practices and in reference to the prior study[1].

2. Method for imaging studies

Imaging studies including US, VCUG and DMSA renal scans, were performed on all patients, except in cases for which it was not possible to obtain parental permission during hospitalization. US was undertaken on the day of admission or on the next day. Abnormalities observed on US were identified as increased echogenicity, dysplasia, bladder anomalies, ureteral dilatation and hydronephrosis. Diagnosis of hydronephrosis was based on the criteria established by the Society for Fetal Urology[10]. VCUG was performed after acute inflammation subsided (negative urine culture and fever subsidence) before patients were discharged from the hospital. A 6 or 8 French Nelaton catheter was inserted into the bladder through the urethra and then connected to a bottle of contrast material; the contrast was dispensed by gravity into the bladder until it was filled. Then a series of images was obtained to determine whether any liquid had traveled backwards into one or both ureters while the patient emptied his or her bladder. VUR grading was based on the criteria of the International Reflux Study in Children[11]. VUR was graded as mild, moderate, or severe: grades I and II correspond to mild, grade III to moderate, and grades IV and V to severe reflux[12]. The patients were divided into two groups according to the results of the VCUG. Patients with an absence of VUR or with mild VUR (I-II) made up Group 1, and those with a VUR grade of III or higher were placed into Group 2. Lower grades of reflux are much more likely to resolve than are higher grades, but children with high grade reflux who acquire a UTI are at significant risk for pyelonephritis and renal scarring.

DMSA scans were performed during hospitalization and again six months later. The scans were performed four to six hours after intravenous injection of an age-adjusted dose of 2 MBq/kg of 99m-Tc-DMSA (minimum dose: 40 MBq, maximum dose: 100 MBq). When possible, pinhole images were obtained in the anterior, posterior, and right and left oblique projections with a 256×256 matrix for a duration of five minutes each with a camera equipped with a high-resolution, low energy collimator.

A kidney uptake of 45-55% of the total renal activity was considered to be normal (symmetrical renal split function)[12]. A positive DMSA result was defined as the presence of any of the following: a cortical defect or scarring; focal or diffuse areas of reduced radionuclide uptake; large, small, or absent kidneys; possible duplex kidney. On the DMSA scan, APN was defined as the presence of focal or diffuse areas of reduced uptake of radionuclide with preservation of the normal reniform outline, or by the presence of diffusely decreased uptake in an enlarged kidney. Renal scarring was

defined by the presence of decreased radionuclide uptake associated with loss of the reniform outline or the presence of cortical thinning with decreased volume[13].

The data were analyzed using SPSS version 12.0 software (SPSS Inc., Chicago, IL, USA). Relationships between variables were studied using the Chi-square test and ANOVA. *P*-values below 0.05 were considered statistically significant.

Results

1. Clinical characteristics in study patients

Out of a total of 180 patients, 112 (62.2%) were urine culture positive and 68 (37.8%) were urine culture negative; 51 (28.3%) were urine nitrite positive and 129 (71.7 %) were urine nitrite negative. The average duration of fever was 4.67 days. The median values of WBC and CRP were 14,820/mm^3, 4.69 mg/dL, respectively. Seventy-one (39.4%) patients presented with leukocytosis (≧15,000/ mm^3) and 78 (43.3%) had an elevated CRP (≧3 mg/dL) on admission. The median durations of fever before and after therapy were 48 and 36 hours, respectively. The number of cases with a duration of fever more than 36 hours after therapy was 55 (30.6%), and 73 (40.6%) patients experienced a duration of fever more than 48 hours prior to therapy (Table 1).

2. Imaging study results

US was performed in 160 (88.9%) of the 180 patients. US was abnormal in 51 (31.9%). VCUG was performed in 148 (82.2%) patients. Of these, 37 (25% patients) had VUR; 18 had grades I and II, 8 had grade III and 11 had grades IV and V. The DMSA scan was performed in 95 patients (52.8%), and 29 (30.5%) of them had cortical defects (Table 2).

In this study, the patients undergoing VCUG with culture negative were 55. Of them 14 (25.5%) had VUR and the prevalence of high grade (III-V) VUR was 7.3% (4/55). The DMSA scans were abnormal in 8 (22.2%) of 36 patients with culture negative.

3. Comparison of clinical variables between grades of VUR

VCUG was performed in 148 patients, and 37 of them had VUR. We divided these 37 cases of VUR into two groups according to the duration of fever after treatment. Eleven cases of one group (fever duration <36 hours) had VUR: eight (72.7%) with grades I or II, three (27.3%) with grade III, and none with grades IV and V. Twenty-four cases of the other group (fever duration ≥36 hours) were diagnosed with VUR : nine (37.5%) with grades I and II, five (20.8%) with grade III, and ten (41.7%) with grades IV and V.

We detected a statistically significant relationship between having a prolonged fever after therapy and the high grade (III-V) VUR (P=0.036). However, we did not detect a statistically significant relationship between fever duration before therapy and the high grade VUR (P>0.05). Both WBC counts (≧15,000/mm^3) and CRP (≧3.0 mg/dL) were elevated in patients who had high grade VUR, and this elevation was the statistically significant (Table 3).

4. Comparison of clinical variables on results of DMSA scans

The relationship between fever duration after therapy

Table 1. Clinical Characteristics of Study Patients

Variables	Patients(n=180)			
	Positive (n)	(%)	Negative (n)	(%)
Urine culture	112	62.2	68	37.8
Urine nitrite	51	28.3	129	71.7
Leukocytosis (≥15,000/mm3)	71	39.4	109	60.6
Elevated CRP (≥3 mg/dL)	78	43.3	102	56.7
Duration of fever after Tx. (≥36 hours)	55	30.6	125	69.4
Duration of fever before Tx. (≥48 hours)	73	40.6	107	59.4

Abbreviations : CRP, C-reactive protein; Tx, Treatment

Table 2. Imaging Study Results

Imaging study	Results	Number (%)
Renal US (n=160)	Normal	109 (67.8%)
	Abnormal	51 (31.9%)
VCUG (n=148)	Normal	111 (75.0%)
	Grade I+II	18 (12.2%)
	Grade III	8 (5.4%)
	Grade IV+V	11 (7.4%)
DMSA scan (n=95)	Normal	66 (69.5%)
	Abnormal	29 (30.5%)

Abbreviations : DMSA, dimercaptosuccinic acid; US, ultrasonography; VCUG, voiding cystourethrogram

Table 3. Comparison of Clinical Variables between Group 1 and Group 2

Variables	VUR				
	Group 1 (%)			Group 2 (%)	
	None (1)	G I, II	(1)+(2)	G III, IV & V	P^*
FD (1)					
〈48 hrs	61 (74.4)	9 (10.9)	70 (85.4)	12 (14.6)	〉0.05
≥48 hrs	52 (78.8)	8 (12.1)	60 (90.9)	6 (9.1)	
FD (2)					
〈36 hrs	69 (86.3)	8 (10.0)	77 (96.3)	3 (3.8)	0.036
≥36 hrs	44 (64.7)	9 (13.2)	53 (77.9)	15 (22.1)	
CRP (mg/dL)					
〈3.0	66 (85.7)	7 (9.1)	73 (94.8)	4 (5.1)	0.002
≥3.0	45 (63.4)	11 (15.5)	56 (78.9)	15 (21.1)	
WBC (/mm^3)					
〈15,000	69 (81.2)	10 (11.8)	79 (92.9)	6 (7.1)	0.01
≥15,000	42(66.7)	8 (12.7)	50 (79.4)	13 (20.6)	

Group 1: Patients without VUR and with VUR grade I, II
Group 2: Patients with VUR grade III, IV & V
FD (1): Duration of fever before therapy
FD (2): Duration of fever after therapy
Abbreviations : VUR, vesicoureteral reflux; G, grade; hrs, hours; CRP, C-reactive protein; WBC, white blood cells

Table 4. Comparison of Clinical Variables with respect to the Results of Dimercaptosuccinic Acid (DMSA) Scans

Variables	DMSA Scan		
	Normal (%)	Abnormal (%)	P
FD (1)			
〈48hrs	34 (69.4)	15 (30.6)	〉0.05
≥48hrs	31 (67.4)	15 (32.6)	
FD (2)			
〈36 hrs	40 (88.9)	5 (11.1)	0.009
≥36 hrs	25 (50.0)	25 (50.0)	
CRP (mg/dL)			
〈3.0	39 (90.7)	4 (9.3)	0.003
≥3.0	27 (51.9)	25 (48.1)	
WBC (/mm^3)			
〈15,000	42 (80.8)	10 (19.2)	0.011
≥15,000	23 (53.5)	20 (46.5)	

FD (1): Duration of fever before therapy
FD (2): Duration of fever after therapy
Abbreviations : CRP, C-reactive protein; WBC, white blood cells; DMSA, Dimercaptosuccinic acid renal scan

and the presence of a cortical defect in the DMSA scan is summarized in Table 4 (P=0.009). Additionally, statistical significance was identified from the comparison of elevated CRP and leukocytosis with results from DMSA scans. In this study, however, clinical variables such as fever duration before therapy and positive urine culture did not predict APN or high grade VUR.

5. Relationship between renal parenchymal lesions in DMSA scans and presence of high grade (III-V) VUR

In 90 patients, VCUG and DMSA scans were performed during the acute phase of UTI. An abnormal DMSA scan was significantly correlated with the presence of high grade VUR (P<0.001). The sensitivity, specificity, and positive and negative predictive values of the DMSA scan in predicting high grade VUR were 64.7%, 69.9%, 33.3% and 89.5 %, respectively (Table 5).

Discussion

Approximately two-thirds of young children with febrile UTI will have APN, which involves infection and inflammation of the kidneys and ureters[14, 15]. Between 15% and 52 % of children with APN will go on to develop subsequent renal scarring[16].

Children with UTIs are screened for VUR because VUR is the strongest predictor of renal scarring. The prevalence of VUR reported in larger epidemiological studies ranges between 30 and 40% for all childhood UTIs[17]. Most observed VUR is a low grade[18]. In some studies, patients with high grade VUR are four to six times more likely to have scarring than those with low grade VUR, and they are also eight to ten times as likely as those with no VUR[18-20]. In the light of long-term prognosis and the need for anti-

Table 5. The Association between Renal Parenchymal Lesions in Dimercaptosuccinic Acid (DMSA) Scans and Presence of High-grade Vesicoureteral Reflux (VUR) (grade III-V)

Results of DMSA scan	Vesicoureteral reflux			
	Group I (%)			Group II (%)
	None	Grade I-II	Total	Grade III-V
Normal	43 (75.4)	8 (14.0)	51 (89.5)	6 (10.5)*
Abnormal	12 (36.4)	10 (30.3)	22 (66.7)	11 (33.3)*

Group 1: Patients without VUR(1) and with VUR grade I, II(2)
Group 2: Patients with VUR grade III, IV & V
*$P<0.001$
Abbreviations : DMSA, dimercaptosuccinic acid renal scan; VUR, vesicoureteral reflux

microbial prophylaxis, our study focused on the detection of high grade VUR. The results of this study revealed that DMSA scanning had a high negative predictive value for ruling out high grade VUR[21], but DMSA scanning had a low positive predictive value. Moreover, high grade VUR was present in 10.5% of patients with normal DMSA scans. A previous study revealed that starting the imaging work-up with an early DMSA scan and only performing VCUG in children with abnormal scans could avoid invasive and uncomfortable VCUGs for a large proportion of children who have DMSA scans[21]. Further studies are warranted to aid in adapting the relevant guidelines.

The DMSA scans were abnormal in 8 (22.2%) of 36 patients with culture negative. These data indicate DMSA scans should be an integral part of the protocol for evaluating every child with a fever of unknown origin[1].

Our data suggest that duration of fever after therapy is significantly associated with the increased development of renal cortical defects. Fernandez-Meneadez et al.[22] showed that the incidence of renal cortical defects was significantly increased in case of fever duration longer than 24 hours after antibiotic use. In contrast, Han et al.[23] reported that the incidence of renal cortical defects remained the same regardless of whether the duration of fever after treatment was longer than 48 hours. However, there was no relationship between fever duration before therapy and renal cortical defects. Stokland et al.[24] revealed that fever duration before therapy was not associated with renal cortical defects. Recently, health information about pediatric UTI has spread through newspapers, internet health counseling sites and broadcasting programs. Patients are more likely to bring febrile children to doctors promptly, and when a child develops a fever of unknown origin, local clinics tend to routinely perform urinalysis, microscopy and urine cultures. Earlier detection, earlier diagnosis of UTIs and prompt antibiotic use have played a role in reducing the duration of fevers associated with UTIs. Durations of fever before therapy are becoming shorter, and the value of fever duration before therapy as a clinical sign has been declining as well.

Our data show there was statistical significance of prolonged fever after therapy, elevated CRP and leukocytosis with the cortical defects on DMSA scan and high grade VUR. There was also a correlation between the DMSA result and the presence of high grade VUR.

The limitations of this study include incomplete work-ups on some patients, and predetermined inclusion criteria with insufficient evidence for culture negative patients.

We recognize the value of clinical signs (prolonged fever after therapy, elevated CRP, leukocytosis) as predictors of APN and high grade VUR.

한 글 요 약

소아 요로 감염 및 의심 환아에서 신 실질 병변 및 방광요관 역류와 임상 변수와의 연관성

건국대학교 의학전문대학원 소아과학교실

변정림 · 이상택 · 정소정 · 김교순

목 적 : 본 연구는 소아 요로 감염증에서 치료 전 발열 기간과 치료 후 발열 기간 등의 임상변수와 혈액 및 소변 등의 검사 결과가 신 실질 병변 및 방광요관 역류 등을 예측하는 데 있어서 인자로 작용할 수 있는지를 평가해 보고자 하였다.

방 법 : 2005년 7월부터 2008년 7월까지 첫 번째 열성 요로 감염으로 본원 소아과에 입원한 1개월부터 만 17세까지의 환아 180명을 대상으로 하였다. 환아의 혈액 검사 소견 중 C-반응 단백, 백혈구수와 소변 검사 중 배양 검사 결과, 소변 질산염 및 치료전 발열기간, 치료 후 발열 기간 등을 변수로 하여 신장 초음

과, 배뇨 방광 요도 조영술, 신 스캔 등의 영상 검사 결과와 비교하여 연관성을 평가하였다.

결 과: C-반응 단백 수치가 높고 백혈구 증가증이 있으며 입원 치료 후 긴 발열 기간을 가진 경우 신 실질 병변이 유의하게 증가하였고 3단계 이상의 방광 요관 역류 발생도 높았다. 신 스캔 검사상 이상 소견을 보인 경우는 신 스캔 검사상 정상 소견을 가진 군과 비교하였을 때 3단계 이상의 방광 요관 역류가 더 증가되어 있었다.

결 론: C-반응 단백 수치, 백혈구 증가증, 입원 치료 후 긴 발열기간 등의 임상 변수는 신 실질 병변과 3단계 이상의 방광 요관 역류의 예측 인자가 될 수 있을 것으로 사료된다.

References

1) Nammalwar BR, Vijayakumar M, Sankar J, Ramnath B, Prahlad N. Evaluation of the use of DMSA in culture positive UTI and culture negative acute pyelonephritis. Indian Pediatr 2005;42:691-6.
2) Camacho V, Estorch M, Fraga G, Mena E, Fuertes J, Hernández MA et al. DMSA study performed during febrile urinary tract infection: a predictor of patient outcome? Eur J Nucl Med Mol Imaging 2004;3:862-6.
3) Eggli DF, Tulchinsky M. Scintigraphic evaluation of pediatric urinary tract infection. Semin Nucl Med 1993;3:199-218.
4) Jacobson SH, EklöfE O, Eriksson CG, Lins LE, Tidgren B, Winberg J. Development of hypertension and uraemia after pyelonephritis in childhood: 27 year follow up. BMJ 1989; 299:703-6.
5) Rushton HG. Urinary tract infections in children: epidemiology, evaluation and management. Pediatr Clin North Am 1997;44:1133-69.
6) Merrick MV, Notghi A, Chalmers N, Wilkinson AG, Uttley WS. Long term follow up to determine the prognostic value of imaging after urinary tract infections. Part 1: Reflux. Arch Dis Child 1995;72:388-92.
7) Merrick MV, Notghi A, Chalmers N, Wilkinson AG, Uttley WS. Long term follow up to determine the prognostic value of imaging after urinary tract infections. Part 2: Scarring. Arch Dis Child 1995;72:393-96.
8) Jung SW, Jung KH, Kim MH, Lee JE, Hong YJ, Son BK. Factors associated with renal scarring in children with a first episode of febrile urinary tract infection. J Korean Soc Pediatr Nephrol 2005;9:56-63.
9) Jung JI, Lim DH, Yim HE, Park MS, Yoo KH, Hong YS et al. Fever duration and renal scar in pediatric urinary tract infection. J Korean Soc Pediatr Nephrol 2008;12:70-7.
10) Keays MA, Guerra LA, Mihill J, Raju G, Al-Ashleri N, Geier P, et al. Reliability assessment of society for fetal urology ultrasound grading system for hydronephrosis. J Urol 2008; 180:1680-2.
11) Lebowitz RL, Olbing H, Parkkulainen KV, Smellie JM, Tamminen-Möbius TE. International system of radiographic grading of vesicoureteric reflux. International reflux study in children. Pediatr Radiol 1985;15:105-9.
12) Silva JM, Diniz JS, Lima EM, Vergara RM, Oliveira EA. Predictive factors of resolution of primary vesico-ureteric reflux: a multivariate analysis. BJU Int 2006;97:1063-8.
13) Piepsz A, Colarinha P, Gordon I, Hahn K, Olilvier P, Roca I, et al. Guidelines for 99m Tc-DMSA scintigraphy in children. Eur J Nucl Med 2001;28:37-41.
14) Hoberman A, Charron M, Hickey RW, Baskin M, Kearney DH, Wald ER. Imaging studies after a first febrile urinary tract infection in young children. N Engl J Med 2003;348: 195-202.
15) Wennerström M , Hansson S, Jodal U, Stokland E. Primary and acquired renal scarring in boys and girls with urinary tract infection. J Pediatr 2000;136:30-4.
16) Jakobsson B, Berg U, Svensson L. Renal scarring after acute pyelonephritis. Arch Dis Child 1994;70:111-5.
17) Downs SM. Technical report: urinary tract infections in febrile infants and young children. The Urinary Tract Subcommittee of the American Academy of Pediatrics Committee on Quality Improvement. Pediatrics 1999;103:e54.
18) Bisset GS 3rd, Strife JL, Dunbar JS. Urography and voiding cystourethrograpy: Findings in girls with urinary tract infection. AJR Am J Roentgenol 1987;148:479-82.
19) Gleeson FV, Gordon I. Imaging in urinary tract infection. Arch Dis Child 1991;66:1282-3.
20) McKerrow W, Davidson-Lamb N, Jones PF. Urinary tract infection in children. Br Med J(Clin Res Ed) 1984;289:299-303.
21) Keren R. Imaging and treatment strategies for children after first urinary tract infect infection. Curr Opin in Pediatr 2007; 19:705-10.
22) Fernández-Menéndez JM, Málaga S, Matesanz JL, Solís G, Alonso S, Pérez-Méndez C. Risk factors in the development of early technetium-99m dimercaptosuccinic acid renal scintigraphy lesions during first urinary tract infection in children. Acta Paediatr 2003;92:21-6.
23) Han HJ, Kim JH, Lee HS, Lee IS. The significance of renal imaging studies in the diagnosis of acute pyelonephritis. J Korean Soc Pediatr Nephrol 2007;2:212-9.
24) Stokland E, Hellström M, Jacobsson B, Jodal U, Lundgren P, Sixt R. Early 99-mTc dimercaptosuccinic acid (DMSA) scintigraphy in symptomatic first-time urinary tract infection. Acta Paediatr 1996;85:430-6.