Relationship Between Uncommon Computed Tomography Findings and Clinical Aspects in Patients With Acute Pyelonephritis

Jang Sik Kim, Sangwook Lee, Kwang Woo Lee, Jun Mo Kim, Young Ho Kim, Min Eui Kim

Department of Urology, Soonchunhyang University College of Medicine, Cheonan, Korea

Purpose: Computed tomography (CT) has become popular in the diagnosis of acute pyelonephritis (APN) and its related complications in adults. The aim of this study was to investigate the relationship between uncommon CT findings and clinical and laboratory data in patients with APN.

Materials and Methods: From July 2009 to July 2012, CT findings and clinical data were collected from 125 female patients with APN. The six uncommon CT findings (excluding a wedge-shaped area of hypoperfusion in the renal parenchyma) studied were perirenal fat infiltration, ureteral wall edema, renal abscess formation, pelvic ascites, periportal edema, and renal scarring. The clinical parameters analyzed were the age and body mass index of the patients as well as the degree and duration of fever. Laboratory parameters related to inflammation and infection included white blood cell count, C-reactive protein (CRP) level, erythrocyte sedimentation rate, pyuria, and bacteriuria.

Results: The most common CT finding was perirenal fat infiltration (69 cases, 55%). A longer duration of fever, higher CRP level, and grade of pyuria were related with perirenal fat infiltration (p=0.010, p=0.003, and p=0.049, respectively). The CRP level was significantly higher in patients with renal abscess and ureteral wall edema (p=0.005 and p=0.015, respectively).

Conclusions: The uncommon CT findings that were related to aggravated clinical and laboratory parameters of APN patients were perirenal fat infiltration, ureteral wall edema, and renal abscess formation. The inflammatory reaction and tissue destruction may be more aggressive in patients with these CT findings.

Keywords: Pyelonephritis; X-ray computed tomography

INTRODUCTION

Acute pyelonephritis (APN) is the most common upper urinary tract infection, and approximately 20% to 35% of females experience an episode of APN in their lifetime [1]. The annual incidence of APN is reportedly as high as 35.7 per 10,000 individuals in South Korea, and the incidence of hospitalization for APN is reportedly 9.96 per 10,000 Korean women [2]. APN usually occurs secondary to an ascending infection of gram-negative bacteria in females, and the diagnosis is made clinically [3]. Computed tomography (CT) has not been primarily applied in patients with APN; it is preferred in patients with diabetes, equivocal diagnoses, no response to antimicrobial treatment, or immunosuppression. CT can provide important information on the range of inflammation and other accompanying complications to help to establish a precise diagnosis [4-6]. The most common radiologic CT finding of APN is a striated or wedge-shaped area of hypoperfusion or mass-like lesion after contrast injection [7,8]. Other uncommon radiologic findings such as perirenal fat infiltration, ureteral wall edema, renal abscess formation, pelvic...
ascites, portal edema, and renal scarring are also observed on CT scans [9,10].

Although the use of CT in the diagnosis of APN has rapidly increased recently, the relationship between APN and CT findings has rarely been reported. We investigated the relationship between uncommon CT findings and clinical parameters in patients with APN.

MATERIALS AND METHODS

1. Inclusion criteria
This retrospective study was approved by the Institutional Review Board of the Soonchunhyang University Bucheon Hospital (IRB no. 2013-07-014). From July 2009 to July 2012, a total of 125 female patients (mean age, 42.8±13.5 years) with APN were included in this study. In all patients, CT showed a wedge-shaped area of hypoperfusion in the renal parenchyma. A clinical diagnosis of APN was made in patients with more than three of the following five diagnostic criteria:

(1) Clinical symptoms such as fever, chills, vomiting, or flank pain
(2) Costovertebral angle tenderness
(3) Fever of more than 37.5°C
(4) Leukocytosis in the complete blood count (>10,000/μL)
(5) Abnormal urine test results (pyuria: white blood cells [WBC] of >5/high-power field [HPF] or positive urine culture of >10^5 colony-forming unit/mL)

2. CT technique
Because CT scans were performed over a period of 3 years, multidetector helical CT of various types with either a 16- or 64-channel multidetector row scanner (Somatom Sensation 16, Siemens Medical Solutions, Erlangen, Germany) or LightSpeed VCT (GE Healthcare Life Sciences, Piscataway, NJ, USA) was applied in all patients. The CT findings were evaluated in the nonenhanced and nephrographic phases. Intravenous contrast material was administered in an antecubital vein with an injector at a dose of 2 mL/kg body weight and rate of 3 mL/s to a maximum of 160 mL. Nephrographic-phase scans were started 90 to 100 seconds after contrast injection.

3. CT findings
The following six uncommon radiologic CT findings were evaluated by one radiologist in our hospital: perirenal fat infiltration, ureteral wall edema, renal abscess formation, pelvic ascites, periportal edema (Fig. 1), and renal scarring.

4. Clinical parameters
We investigated age, degree and duration of fever, body mass index (BMI), blood leukocytosis, hemoglobin (Hb), erythrocyte sedimentation rate (ESR), C-reactive protein (CRP) level, grade of pyuria, and positive urine/blood culture. Pyuria was graded from 1 to 6 by microscopic examination under HPF (grade 1, 0–1 WBC/HPF; grade 2, 1–4 WBC/HPF; grade 3, 5–9 WBC/HPF; grade 4, 10–29 WBC/HPF; grade 5, 30–50 WBC/HPF; grade 6, more than half the HPF filled with WBC).

5. Statistical analysis
The statistical analysis was performed by using SPSS ver. 14 (SPSS Inc., Chicago, IL, USA). Student t-test or the Mann-Whitney U-test was applied to compare the clinical parameters of fever, BMI, WBC count, Hb level, ESR, CRP level, grade of pyuria, and presence of the six CT findings described above. The chi-square test was used to evaluate differences between the presence of bacteriuria/bacteremia and the presence of the six CT findings. Values of p<0.05 were considered to indicate statistical significance.

### Table 1. Patients’ characteristics

| Characteristic            | Value          |
|---------------------------|----------------|
| Age (y)                   | 42.8±13.5      |
| Body mass index (kg/m²)   | 22.9±3.7       |
| Recurrent cases           | 22 (17.6)      |
| Laterality                |                |
| Left                      | 36 (28.8)      |
| Right                     | 62 (49.6)      |
| Bilateral                 | 27 (21.6)      |
| Diabetes mellitus         | 12 (9.6)       |
| Creatinine (mg/dL)        | 0.9±0.1        |
| Peak fever (°C)           | 38.7±0.8       |
| Duration of fever (d)     | 7.3±3.1        |
| White blood cell (μL)     | 11,733±4,665   |
| Erythrocyte sedimentation rate (mm/h) | 46.5±25.1 |
| C-reactive protein (mg/dL)| 12.8±7.5       |
| Mean pyuria (grade)       | 4.6±1.2        |
| Positive urine culture    | 74 (59.2)      |

Values are presented as mean±standard deviation or number (%).
RESULTS

The mean peak fever was 38.7°C±0.8°C, and the mean fever duration was 7.3±3.1 days. The mean blood leukocyte count was 11,733±4,665 /μL, the mean CRP level was 12.8±7.5 mg/dL, and the mean grade of pyuria was grade 4.6±1.2 (Table 1). The most common CT finding was perirenal fat infiltration (69 cases, 55%), followed in turn by pelvic ascites (50 cases, 40%), ureteral wall edema (39 cases, 31%), and renal abscess formation (20 cases, 16%; Table 2).

When we compared the six CT findings with the clinical parameters, the fever duration was longer and the CRP level and grade of pyuria were higher in cases with perirenal fat infiltration (p=0.010, p=0.033, and p=0.049, respectively). The CRP level was significantly higher in patients with renal abscess formation and ureteral wall edema (p=0.005 and p=0.015, respectively). Pelvic ascites, perirenal edema, and renal scarring had no relationship with clinical parameters (Table 3). Although bacteriuria was found in 74 patients (59.2%), bacteriuria positivity was not related to any of the CT findings (Table 3).

DISCUSSION

APN is usually diagnosed on the basis of typical clinical symptoms (fever, chills, nausea, and flank pain), physical examination findings (costovertebral angle tenderness), and laboratory findings including leukocytosis, pyuria, and a positive urine culture [3]. The clinical risk factors of APN are female gender, diabetes mellitus, immunosuppression, postmenopausal state, previous recurrent urinary tract infection, and vesicoureteral reflux [11]. Although intravenous pyelography (IVP) and renal

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**TABLE 2. Incidence of six computed tomography (CT) findings in acute pyelonephritis**

| CT finding                      | Present | Absent |
|---------------------------------|---------|--------|
| Perirenal fat infiltration      | 69 (55) | 56 (45) |
| Ascites                         | 50 (40) | 75 (60) |
| Ureteral wall edema             | 39 (31) | 86 (69) |
| Renal abscess                   | 20 (16) | 105 (84) |
| Perirenal edema                 | 15 (12) | 110 (88) |
| Renal scarring                  | 11 (8)  | 114 (92) |

Values are presented as number (%).

**TABLE 3. Correlations between computed tomography findings and clinical and laboratory parameters**

| Variable            | Renal abscess\(^a\) | Perirenal fat infiltration\(^b\) | Ureteral wall edema |
|---------------------|----------------------|----------------------------------|---------------------|
| Age (y)             | (n=20)               | (n=69)                           | (n=39)              |
| Peak fever (°C)     |                      |                                  |                     |
| Duration of fever (d) |                     |                                  |                     |
| WBC (μL)            | 13,803±5,815         | 11,027±4,730                     | 12,063±4,565        |
| Hb (g/dL)           | 11.4±1.3             | 11.7±1.2                         | 11.4±1.3            |
| ESR (mm/h)          | 55.5±28.1            | 45.2±25.0                        | 45.5±25.8           |
| CRP (mg/dL)         | 16.8±7.4             | 12.2±7.4                         | 14.1±7.9            |
| Pyuria (grade)      | 4.5±1.2              | 4.7±1.2                          | 4.9±1.2             |
| Bacteriuria (%)     | 11 (55.0)            | 63 (60.0)                        | 38 (55.1)           |
| p-value             |                     |                                  | 0.297               |
|                     |                      |                                  | 0.988               |
|                     |                      |                                  | 0.998               |
|                     |                      |                                  | 0.005               |
|                     |                      |                                  | 0.015               |
|                     |                      |                                  | 0.121               |
|                     |                      |                                  | 0.081               |
|                     |                      |                                  | 0.055               |
|                     |                      |                                  | 0.055               |
|                     |                      |                                  | 0.480               |
|                     |                      |                                  | 0.097               |
|                     |                      |                                  | 0.984               |
|                     |                      |                                  | 0.258               |
|                     |                      |                                  | 0.992               |
|                     |                      |                                  | 0.064               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 7.9±3.5             |
|                     |                      |                                  | 6.5±2.2             |
|                     |                      |                                  | 7.3±2.5             |
|                     |                      |                                  | 7.3±3.3             |
|                     |                      |                                  | 0.010               |
|                     |                      |                                  | 0.278               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 0.064               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 7.9±3.5             |
|                     |                      |                                  | 6.5±2.2             |
|                     |                      |                                  | 7.3±2.5             |
|                     |                      |                                  | 7.3±3.3             |
|                     |                      |                                  | 0.010               |
|                     |                      |                                  | 0.278               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 7.9±3.5             |
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|                     |                      |                                  | 7.3±2.5             |
|                     |                      |                                  | 7.3±3.3             |
|                     |                      |                                  | 0.010               |
|                     |                      |                                  | 0.278               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 7.9±3.5             |
|                     |                      |                                  | 6.5±2.2             |
|                     |                      |                                  | 7.3±2.5             |
|                     |                      |                                  | 7.3±3.3             |
|                     |                      |                                  | 0.010               |
|                     |                      |                                  | 0.278               |
|                     |                      |                                  | 0.033               |
|                     |                      |                                  | 0.033               |

Values are presented as mean±standard deviation or number (%).

WBC, white blood cells; Hb, hemoglobin; ESR, erythrocyte sedimentation rate; CRP, C-reactive protein.
\(^a\)Mann-Whitney U-test. \(^b\)Student t-test.
of choice for renal abscesses, in which cases a focal rounded area of decreased enhancement is usually found [18].

Neither bacterial ureteritis nor pyeloureteritis have been reported in the literature because of their rarity as separate disease entities and because of difficulties in their precise diagnosis. The clinical significance and pathophysiology of ureteral wall or pelvicalyceal wall thickening in APN are also unknown for these reasons. Both renal abscess formation and ureteral wall thickening were risk factors for an increased CRP level in our study, and we regarded ureteral wall or pelvicalyceal wall thickening as an indicator of severe inflammation of the pelvicalyceal system or ureter and of ascending infection. Tsugaya et al. [10] reported that cortical scars were detected in six of seven patients in whom the inflammatory lesions occupied 30% or more of the renal parenchyma. Because we performed CT scans at admission, our renal CT scan findings seemed to be evidence of previous recurrent or severe renal inflammation. Although the CT finding of renal scarring was not related with the severity of inflammation and clinical parameters in our study, a follow-up CT scan or diuretically produced renal scan may be needed in patients with severe inflammation, even in adults.

Periportal edema and ascites are nonspecific radiologic findings representing accumulation of fluid within third spaces [19]. The periportal region is the area around the portal vein and its branches, within which the hepatic artery, bile duct branches, autonomic nerves, and lymphatics are found [20]. The other radiologic findings associated with hepatic periportal tracking include a thickened gallbladder wall, pleural effusion, and a dilated inferior vena cava [21]. A multifactorial etiology for periportal edema in acute infectious disease has been suggested, including altered sodium reabsorption as a result of the infectious process involving the renal interstitium and increased vascular permeability secondary to systemic sepsis or hypoalbuminemia [21].

Our study had several limitations. First, we did not include the most frequent CT finding in APN, namely, a focal or multifocal wedge-shaped area of hypoperfusion, because all patients had this finding and it was difficult to quantify. Exclusion of patients with only CT findings of a wedge-shaped area of hypoperfusion may be the reason for the relatively small number of cases in our study. Second, we used a retrospective design, and many other intrarenal and extrarenal findings were not included because of their low incidence, which was also likely due to the relatively small number of cases.

CONCLUSIONS

The uncommon CT findings that were related with aggravated clinical and laboratory parameters of APN were perirenal fat infiltration, ureteral wall edema, and renal abscess formation. The inflammatory reaction and tissue destruction may be more aggressive in patients with these CT findings. These results may helpful in terms of predict-
ing the clinical course and creating a treatment plan for patients with APN.

CONFLICTS OF INTEREST
The authors have nothing to disclose.

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