

## Gallbladder Wall Thickening and Periportal Tracking on CT in Patients with Acute Pyelonephritis

급성신우신염 환자의 전산화단층촬영에서 관찰되는 담낭벽의 비후와 간문맥 주위 저음영에 관한 연구

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**Purpose:** To assess gallbladder (GB) wall thickening and periportal tracking on CT in patients with acute pyelonephritis (APN) by each kidney involvement.

**Materials and Methods:** A total of 117 patients diagnosed with APN by clinical examination and CT were included in this retrospective study. The patients were divided into three groups based on kidney involvement seen on CT: right APN, left APN, and bilateral APN. Two radiologists reviewed CT images in consensus for the presence of diffuse GB wall thickening and periportal tracking. The prevalence of these two manifestations was compared among the three groups.

**Results:** The prevalence of GB wall thickening in patients with right APN (26.4%) and bilateral APN (19%) was significantly higher than in patients with left APN (0%) ( $p < 0.016$ ). The prevalence of periportal tracking in patients with right APN (15.1%) and bilateral APN (26%) was higher than in patients with left APN (3%), with a significant difference between patients with bilateral APN and left APN ( $p < 0.016$ ).

**Conclusion:** GB wall thickening and periportal tracking are predominantly encountered on CT in patients with APN involving the right kidney (right and bilateral APN), and should be considered in differential diagnosis of diseases associated with GB wall thickening and periportal tracking.

### Index terms

Acute Pyelonephritis  
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## INTRODUCTION

Diffuse gallbladder (GB) wall thickening is a nonspecific finding, and may be seen in a variety of pathologic conditions extrinsic to the biliary tree, which include hepatitis, heart failure and hypoalbuminemia (1). Periportal tracking is also a nonspecific finding, and can be detected in cases of cirrhosis, hepatitis, hepatic masses, biliary obstruction, congestive heart failure, liver transplant recipients and bone marrow transplant recipients (2, 3).

Several studies found that patients with acute pyelonephritis (APN) occasionally have diffuse GB wall thickening and periportal tracking on CT imaging (4-7). Moreover, GB wall thickening and periportal tracking were the most frequent extra-re-

nal findings of APN, present in more than one-third of cases (4, 7). Accordingly, GB wall thickening and periportal tracking should not be misdiagnosed as acute cholecystitis or hepatic disease in patients with APN (4). However, to our knowledge, GB wall thickening and periportal tracking have not yet been discussed by kidney laterality involved by APN. On the basis of previous studies and also our own institutional experience that GB wall thickening and periportal tracking were visible predominantly in patients with APN involving the right kidney, we hypothesized that APN involving the right kidney, but not the left, may be associated with GB wall thickening and periportal tracking. Therefore, our study aimed to assess GB wall thickening and periportal tracking identified on computed tomography (CT) in patients with APN according to the involve-

ment of each kidney.

## MATERIALS AND METHODS

### Patients

This study was approved by our Institutional Review Board, and informed consent was waived because of the retrospective nature of the study. We reviewed the computerized medical records at our medical center and found a total of 1731 patients who were admitted with APN from January 2004 to July 2009. Clinical presentations of APN included fever, flank pain, urinary symptoms, abnormal urine dipstick test, and positive urine culture. Some of these patients had undergone CT to confirm the diagnosis, to identify high-risk patients, and to determine the extent of disease (8, 9). Contrast-enhanced abdominal CT was performed in 311 patients during hospitalization. From this group of cases, all patients that had CT images of the abdomen were included for review. This selection process was used to identify a group with APN on CT. The CT findings were compatible with APN in 189 of the 311 patients. Seventy two patients were then excluded according to the following criteria: A) patients with abnormal liver function tests, B) patients with evidence of hepatitis or cirrhosis, C) patients with GB and biliary tree abnormalities (GB stone, cancer, cholecystitis, etc.), and D) patients with congestive heart failure. A total of 117 patients (age range: 18-84 years, mean: 50.2 years) were included in our study. Seven patients were men (age range: 63-84 years, mean: 70.1 years), and 110 were women (age range: 18-83 years, mean: 48.9 years).

### CT Technique

CT images were obtained using a 4- or 64-MDCT scanner (4-MDCT Volume Zoom, Siemens Medical Solutions, Iselin, NJ, USA; 64-MDCT Brilliance 64, Philips Medical Systems, Cleveland, OH, USA). Contrast-enhanced CT scans were performed in all patients from the level above the diaphragm to the symphysis pubis during a single breath hold with patients in the supine position. Biphasic (unenhanced and nephrographic phases) or triphasic (unenhanced, corticomedullary, and excretory phases) CT scans were obtained. The scan delay time ranged from 30 to 40 seconds for the corticomedullary phase and from 80 to 100 seconds for the nephrographic phase.

The excretory phase scans were obtained 5 minutes after contrast injection.

All patients received 120-150 mL of iopromide (Ultravist 300, Bayer Healthcare, Berlin, Germany) through an 18 or 20 gauge angiocatheter inserted into a forearm vein. The contrast material was injected at a rate of 3 mL/s using an automatic power injector. Scanning parameters for 4-MDCT were as follows:  $4 \times 2.5$  mm detector collimation, 120 kVp, 130 mAs, 5 mm slice thickness, and 5 mm reconstruction interval. Parameters for 64-channel MDCT were as follows:  $64 \times 0.625$  mm detector collimation, 120 kVp, 300 mAs, 5 mm slice thickness, and 5 mm reconstruction interval.

### Imaging Analysis

CT findings positive for APN were defined as follows: low-density wedge-shaped areas of kidneys, poor corticomedullary differentiation, striated bands of alternating hyper- and hypodensity parallel to the axes of the tubules and collecting ducts, and focal or global renal enlargement (8, 9). The images were reviewed by two radiologists (one radiologist with 14 years of experience in body imaging and a third-year radiology resident) working together and the findings were agreed upon by consensus. The readers were aware that the patients had APN. The presence of GB wall thickening and periportal tracking was then analyzed in conjunction with the diagnosis of APN. GB wall thickening in our study was defined as diffuse submucosal wall thickening more than 3 mm. Irregular or focal thickening was not considered to be GB wall thickening. Periportal tracking was defined as a circumferential zone of low attenuation identified around the peripheral or segmental portal venous branches.

### Statistical Analysis

The patients with APN demonstrated on CT were divided into three groups according to the involvement of each kidney: right APN, left APN, and bilateral APN. Fisher's exact test was used to evaluate the differences in prevalence of GB wall thickening and periportal tracking between the three groups. Null hypotheses of no difference were rejected if *p*-values were less than 0.05. Multiple comparisons were performed between two groups (right APN group vs. left APN group, bilateral APN group vs. left APN group, right APN group vs. bilateral APN group).

Bonferroni's correction was performed for multiple comparisons, with a level of significance less than 0.016 (0.05/3). All statistical analyses used a commercially-available statistical software program (SPSS V11.0K, SPSS Inc., Chicago, IL, USA).

## RESULTS

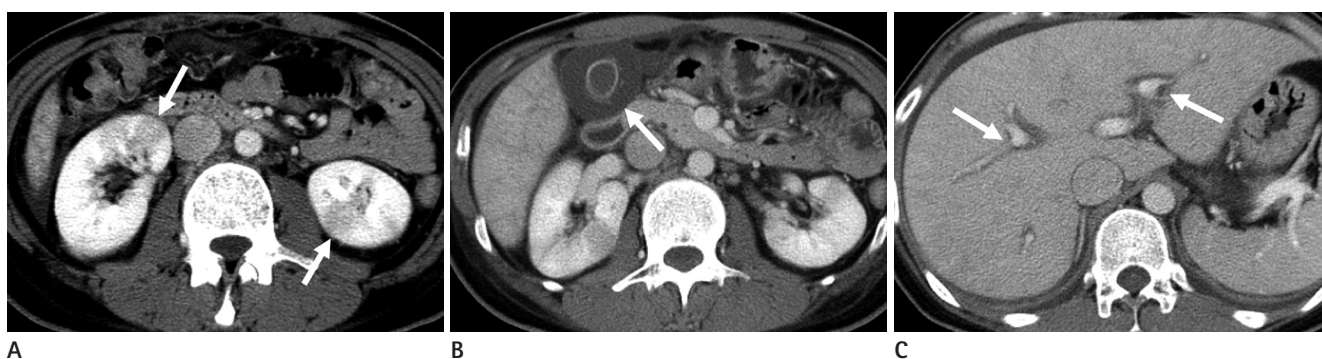
Among 117 patients, 53 (45.3%) patients had right APN, 33 (28.2%) patients had left APN, and 31 (26.5%) patients had bilateral APN on CT, respectively. A total of 20 patients (right APN, 14; bilateral APN, 6) had GB wall thickening present on CT scan. GB wall thickening was not demonstrated on CT in any patients with left APN. A total of 17 patients (right APN, 8; bilateral APN, 8; left APN, 1) had periportal tracking. Table 1 summarizes the prevalence of GB wall thickening and periportal tracking in the three groups. Six patients with bilateral APN

(Fig. 1) and four patients with right APN (Fig. 2) had GB wall thickening and periportal tracking simultaneously. There were significant differences in the prevalence of GB wall thickening ( $p = 0.002$ ) and periportal tracking ( $p = 0.026$ ) among the three groups. The bilateral APN group had a significantly higher prevalence of GB wall thickening ( $p = 0.010$ ) and periportal tracking ( $p = 0.012$ ) than the left APN group. The right APN group also had a higher prevalence of GB wall thickening than

**Table 1. Prevalence of Gallbladder Wall Thickening and Periportal Tracking according to APN Involvement of Each Kidney**

Disease Location	Gallbladder Wall Thickening	Periportal Tracking
Right APN ( $n = 53$ )	26.4% (14/53)	15.1% (8/53)
Left APN ( $n = 33$ )	0% (0/33)	3.0% (1/33)
Bilateral APN ( $n = 31$ )	19.4% (6/31)	25.8% (8/31)
Total ( $n = 117$ )	17.1% (20/117)	14.5% (17/117)

Note.—APN = acute pyelonephritis

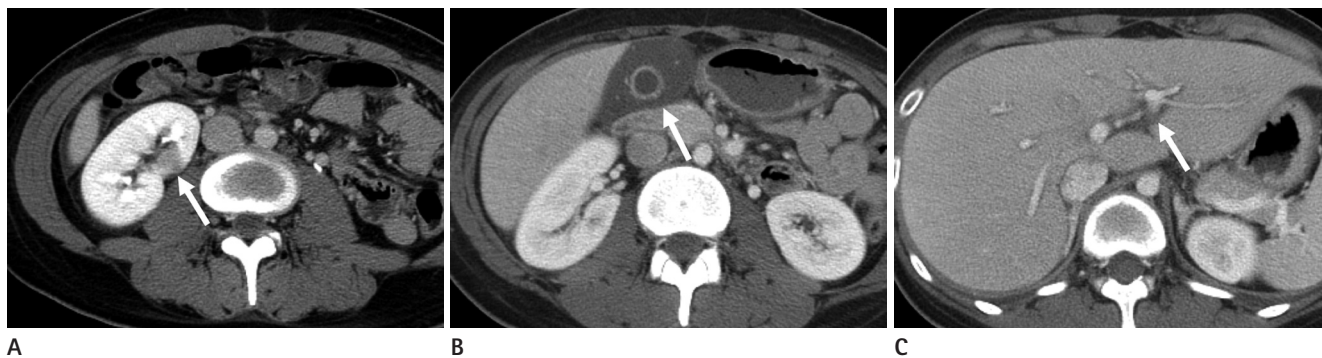


**Fig. 1.** A 36-year-old woman with fever and bilateral flank pain.

**A.** Axial contrast-enhanced CT scan demonstrates wedge shaped hypoattenuating area within the bilateral kidneys (arrows), features consistent with bilateral APN.

**B, C.** CT scans show thick-walled GB that contains hypodense outer layer corresponding to subserosal edema (arrow in **B**) and periportal tracking (arrows in **C**) in the liver.

Note.—APN = acute pyelonephritis, GB = gallbladder



**Fig. 2.** A 22-year-old woman with right flank pain.

**A.** Axial contrast-enhanced CT scan demonstrates wedge shaped hypoattenuating area within right kidney (arrow), features consistent with right APN.

**B, C.** CT scans show edematous GB wall thickening (arrow in **B**) and periportal tracking (arrow in **C**) in the liver.

Note.—APN = acute pyelonephritis, GB = gallbladder

the left APN group ( $p = 0.001$ ). However, there was no significant difference in the prevalence of periportal tracking between the two groups ( $p = 0.144$ ). No statistically significant differences were seen in the prevalence of GB wall thickening and periportal tracking in the right APN group and the bilateral APN group. Table 2 shows multiple comparisons of the prevalence of GB wall thickening and periportal tracking among the three groups.

## DISCUSSION

APN is an acute inflammatory and infectious process of the renal parenchyma and collecting system. Generally, the diagnosis is reached by considering a combination of typical clinical features and laboratory findings. Typical clinical features include fever, flank pain, urinary frequency, and dysuria (10). Imaging studies may not be generally performed in patients with uncomplicated APN (8). However, when complications such as abscess or obstruction are suspected, CT is often performed.

In APN, CT is an important imaging modality to confirm the diagnosis in clinically uncertain cases of renal infection, to identify high-risk patients, and to determine the boundary of disease in suspected complicated cases (11-14). Typical renal CT findings of APN obtained during the cortical and parenchymal nephrographic phases are wedge-shaped hypoattenuated areas of cortex and poor corticomedullary differentiation, probably corresponding to lobar or sublobar segments with poor perfusion and edema (8, 9). Delayed CT scans obtained during the excretory phase often show striated bands of alternating hyper- and hypoattenuation parallel to the axes of the tubules and collecting ducts. However, extrarenal CT manifestations of APN, which include GB wall thickening, periportal

tracking, inferior vena cava dilatation, ascites and pleural effusion, have been less frequently reported (4-7). Moreover, the pathogenesis of extrarenal manifestations such as GB wall thickening and periportal tracking is uncertain in patients with APN.

Diffuse GB wall thickening has been regarded as proof of intrinsic disease of the GB, and it is a well-known hallmark feature of acute cholecystitis. However, diffuse GB wall thickening may occur in patients who do not have a primary GB disease, but in whom the GB is secondarily involved in an extrinsic pathologic condition (15). Periportal tracking, which reflects altered hepatic lymphatic dynamics, has been described in various intra- and extrahepatic diseases (2).

In patients with APN, the pathophysiology of GB wall thickening and periportal tracking may be multifactorial; altered sodium reabsorption as a result of the infectious process involving the renal interstitium, increased vascular permeability complicating severe systemic sepsis or secondary to hypoalbuminemia (4). However, these possibilities do not explain the predominance of GB wall thickening and periportal tracking in patients with APN involving the right kidney. The overall prevalence of GB wall thickening was 17.1% (20/117) while periportal tracking in our study was 14.5% (17/117), lower than the values reported in prior studies, in which more than three-fourths of the patients had APN involving the right kidney (4, 7). A reason for this may be that a relatively large number of patients had APN exclusively involving the left kidney in our study.

Theoretically, GB wall thickening may be caused by any inflammation that extends to the region of the GB (15). Talarico and Rubens (6) reported diffuse GB wall thickening in three women with right-sided APN. They proposed that the etiology of GB wall thickening seen in their patients was contiguous inflammation within the right kidney similar to that seen in peptic disease and acute pancreatitis. In our study, diffuse GB wall thickening was not observed in patients with APN exclusively involving the left kidney. Zissin et al. (5) reported periportal tracking in three women with APN that involved the right kidney. In our study, periportal tracking was found in only one of the patients with APN exclusively involving the left kidney.

It is important to note that GB wall thickening and periportal tracking could be related to abnormalities of lymphatic drainage both directly and indirectly. In a classic study in 1935, Parker (16) showed lymphatic drainage from the normal kidney. In

**Table 2. Multiple Comparisons of the Prevalence of Gallbladder Wall Thickening and Periportal Tracking among Three Groups**

Parameter	Prevalence	p Value
Gallbladder wall thickening		
Right APN vs. Left APN	26.4% vs. 0%	0.001
Left APN vs. Bilateral APN	0% vs. 19.4%	0.010
Right APN vs. Bilateral APN	26.4% vs. 19.4%	0.598
Periportal tracking		
Right APN vs. Left APN	15.1% vs. 3.0%	0.144
Left APN vs. Bilateral APN	3.0% vs. 25.8%	0.012
Right APN vs. Bilateral APN	15.1% vs. 25.8%	0.259

Note.—APN = acute pyelonephritis

his study, the primary sites of drainage for the right kidney were the precaval, postcaval, and interaortocaval nodes. On the other hand, the lymphatics from the left kidney drained through the para-aortic, preaortic, and postaortic nodes. The lymphatics from the liver and GB mainly extend to the hepatoduodenal ligament (17, 18). The abdomino-aortic lymph nodes, especially the nodes in the interaortocaval space, are extremely important, their main function being to receive the lymphatics from the GB (18). Even though numerous lymphatics course in Gerota's fascia and the perinephric fat and may spread along various routes (19), the infection may spread through the lymphatics from the right kidney to the GB via the interaortocaval nodes. In addition to the proximity between the liver, GB and right kidney, infection spreading through the lymphatic connections may explain the higher prevalence of GB wall thickening and periportal tracking in the patients with APN involving the right kidney in our study. Therefore, awareness of APN involving the right kidney as a cause of GB wall thickening and periportal tracking is important in the assessment of CT images in patients with APN.

Our study has some limitations. First, because our study was retrospective, it might have selection bias. The patients were taken from a select group of patients having APN demonstrated on CT. The sensitivity and specificity of CT in the diagnosis of acute pyelonephritis are estimated at 86.8% and 87.5%, respectively (20). Therefore, some of the patients with APN that might not be observed on the CT images were not included in this study. Second, all images were interpreted in consensus by two radiologists without evaluation of interobserver agreement. Furthermore, because the readers were not blinded to the fact that the patients had APN when assessing the GB wall thickening and periportal tracking, there could be bias in interpretation. Third, our CT protocol was not uniform and various CT scanners were used because our study was retrospective. A final limitation of our study is that we did not assess the relationship between the severity of APN and the extrarenal manifestations. The presence of diffuse GB wall thickening in cirrhotic patients is associated with clinical/laboratory variables (21). A prospective study involving more patients is warranted to correlate the extrarenal manifestations with the severity of the illness.

In conclusion, GB wall thickening and periportal tracking are predominantly encountered on CT in patients with APN

involving the right kidney (right and bilateral APN). APN involving the right kidney should be considered in the differential diagnosis of diseases associated with GB wall thickening and periportal tracking.

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## 급성신우신염 환자의 전산화단층촬영에서 관찰되는 담낭벽의 비후와 간문맥 주위 저음영에 관한 연구

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**목적:** 급성신우신염 환자의 복부단층촬영에서 보이는 담낭벽의 비후 및 간문맥 주위 저음영을 평가하여 침범한 신장의 위치에 따라 어떻게 다른지 비교해 보고자 한다.

**대상과 방법:** 임상적 검사와 복부단층촬영에서 급성신우신염으로 진단받은 117명의 환자를 대상으로 하였다. 환자들은 병변의 위치에 따라 3가지 군으로 나누었다(우측 급성신우신염, 좌측 급성신우신염, 양측 급성신우신염). 두 명의 영상의학과 의사가 서로 간의 합의하에 담낭벽의 비후와 간문맥 주위 저음영의 유무에 대해 평가하였다. 두 가지 소견들의 빈도에 대해 3가지 군 간에 비교를 시행하였다.

**결과:** 담낭벽 비후의 빈도는 우측 급성신우신염군(26.4%)과 양측 급성신우신염군(19%)이 좌측 급성신우신염군(0%)과 비교하였을 때 통계적으로 유의하게 높았다( $p < 0.016$ ). 간문맥 주위 저음영의 빈도는 우측 급성신우신염군(15.1%)과 양측 급성신우신염군(26%)이 좌측 급성신우신염군(3%)보다 높았으며, 양측 급성신우신염군과 좌측 급성신우신염군 사이에 통계적으로 유의한 차이를 보였다( $p < 0.016$ ).

**결론:** 담낭벽의 비후와 간문맥 주위 저음영은 주로 우측 신장을 침범한 급성신우신염(우측 급성신우신염과 양측 급성신우신염) 환자의 전산화단층촬영에서 관찰된다. 우측 신장을 침범한 급성신우신염은 담낭벽의 비후와 간문맥 주위 저음영을 일으키는 질환으로 감별진단에 포함될 수 있을 것이다.

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