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# Comparison of reliabilities of the delayed images of helical renal CT in detecting small renal masses

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**Abstract**

The reliabilities of the delayed images of helical computed tomography (CT) in detecting renal mass lesions of 30 mm or less in diameter was compared. Nephrographic, excretory and nephrographic + excretory phase images of all patients were evaluated separately to detect mass lesions of $\leq 5$ and 5–30 mm. There was not any statistically significant difference in the results of three groups. Nephrographic, excretory and nephrographic + excretory phase images are not different from or superior to each other in lesion detection. 

*Keywords:* Computed tomography; Helical; Renal masses; Detection; Delayed scans

## 1. Introduction

A routine abdominal computed tomography (CT) examination is usually performed at contiguous intervals of 7–10 mm beginning 60–70 s after initiation of the contrast injection. These parameters are generally appropriate for the evaluation of visceral organs, such as pancreas and liver. However, with this scan delay, kidneys are scanned in the corticomedullary phase of the renal enhancement. The recent studies have shown that corticomedullary phase images, alone, are not sufficient in lesion detection so that delayed images with thinner image collimation may be required. For the patients undergoing routine abdominal CT with a suspected renal mass, because of the significant risk of missing the lesion, the increased radiation exposure associated with the additional delayed scans has been reported to appear justified. For the patients without a suspected renal mass, the clinical benefits versus the cost and radiation exposure of the delayed scans was suggested to be controversial. However, still, there are not so many studies about the optimal timing of the delayed images in lesion detection [1–4].

The purpose of this study is to compare the reliabilities of the delayed phase images of helical CT in detecting renal mass lesions of $<30$ mm.

## 2. Materials and methods

Twenty patients, who were known to have one or more renal mass lesions according to recent radiological examinations and for whom CT examinations were planned, were included in this study. Ten patients were men, 10 were women (33–69 years old). All patients had two kidneys so 40 kidneys were examined with helical CT (Somatom AR Star, Siemens, Erlangen, Germany). After an anteroposterior topogram of the abdomen, unenhanced renal scans were obtained with a collimation of 4 mm at a pitch ratio of 1:1. After this step, a total volume of 120-ml nonionic contrast agent (350 mg I/ml) was administered through an antecubital vein as a uniphasic bolus at a rate of 2 ml/s. Fifty seconds after the initiation of the contrast injection, a routine abdominal CT examination from the subdiaphragmatic area to the pelvic inlet was performed (collimation: 8 mm, pitch

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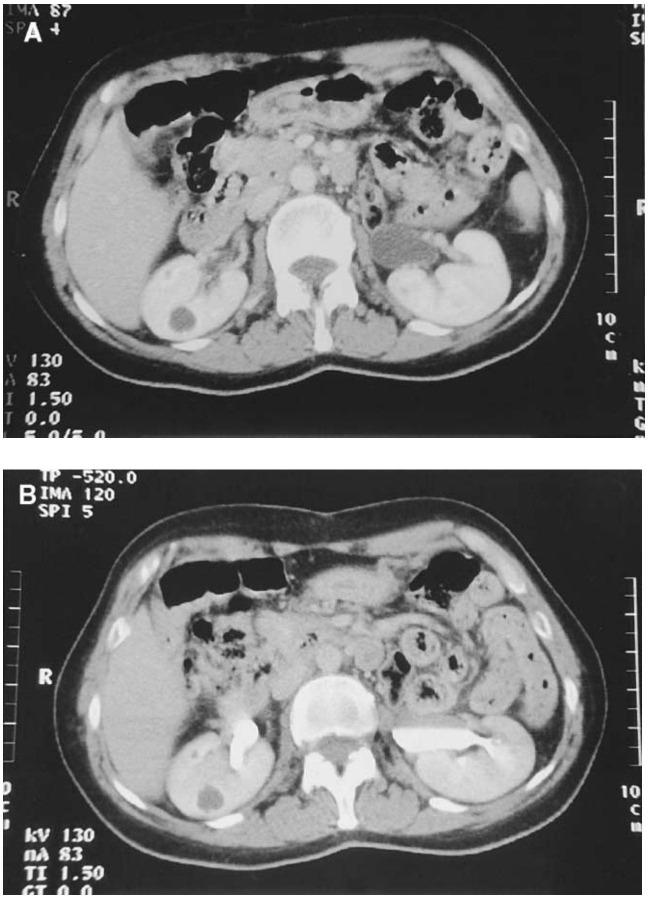


Fig. 1. Nephrographic phase image (A) and excretory phase image (B) of the kidneys. The two lesions in the right kidney, one of which was ≤ 5 mm and the other was >5 mm, were detected in all three groups.

ratio: 1.5:1). Then, nephrographic (N) and excretory phase (E) images of the kidneys were obtained (collimation: 4 mm, pitch ratio: 1:1) 110 and 300 s, respectively, after the initiation of the contrast injection. Thus, the examination was completed. All the examinations were performed by the same radiologist. Two radiologists, one of whom had performed the examinations, together, reviewed both the N and E phase images of all patients, detected the mass lesions of < 30 mm and classified them as ≤ 5 and > 5 mm. These observers compared the N phase images of all patients with the E phase images subjectively for radiological image quality and radiological self-confidence. Also, they evaluated the E phase images for the streak artifacts that occurred from concentrated contrast material in the renal collecting systems. Two other radiologists, who were uninformed of the examinations, together, evaluated the N phase images and, after a period of 1 week for minimizing recall bias, evaluated the E phase images of all patients for the same purpose. All the observers had 3–4 years of radiological experience. The results of three groups for every kidney were compared with each other statistically using reliability analysis intraclass correlation (SPSS 9.05 for Windows).

## 3. Results

For the lesions which were > 5 mm, the results of N phase group, E phase group and N + E phase group were completely the same (Fig. 1A,B). Sixty-five lesions in 40 kidneys were detected. Sixty-two lesions were cysts of category 1 or 2 according to Bosniak classification. Three lesions were accepted as angiomyolipomas or lipomas with the demonstrated fat content and characteristic Hounsfield units on CT.

N phase group, E phase group and N + E phase group detected 139 lesions, 88 lesions and 84 lesions of ≤ 5 mm, respectively (Fig. 2A,B). These lesions could not be characterised because of their size.

For the lesions which were ≤ 5 mm, when N phase group was compared with N + E phase group, the results were concordant in 16 kidneys. In 23 kidneys, 58 lesions (1–7 lesions in one kidney) were detected in N phase group, but not in N + E phase group. On the other hand, in 2 kidneys, 3 lesions (1–2 lesions in one kidney) were detected in N + E phase group, but not in N phase group. When E phase group was compared with N + E phase, the results

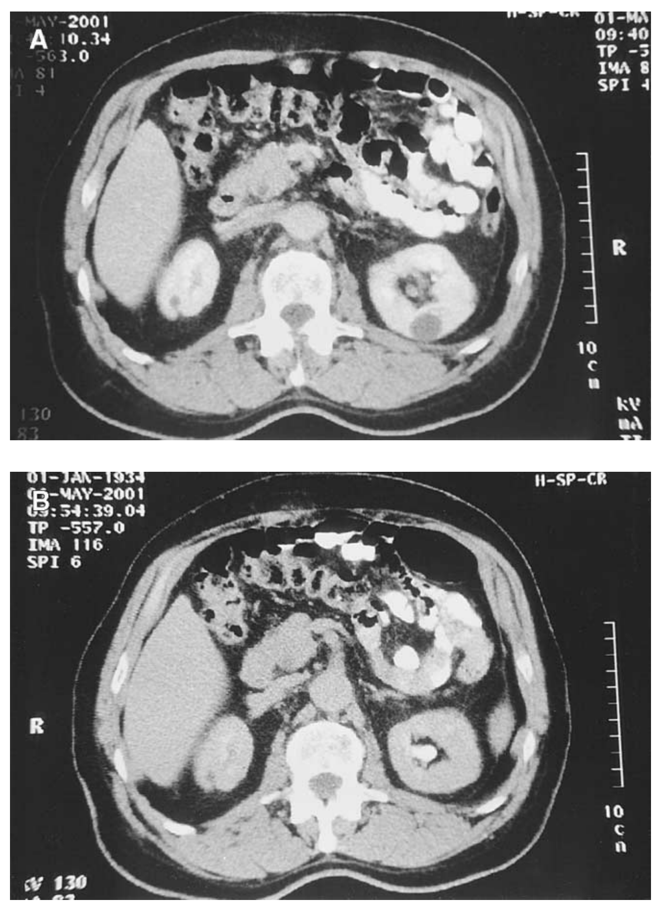


Fig. 2. Nephrographic phase image (A) and excretory phase image (B) of the kidneys. Nephrographic and nephrographic + excretory phase groups accepted the area in the posterior aspect of the right kidney as a lesion. Excretory phase group commented this area as a pseudolesion.

Table 1
Summary of concordant and discordant findings for ≤5 mm lesions in three groups

| | Concordance | Discordance | |
|---|---|---|---|
| (N) − (N+E) | 16 kidneys | 58 lesions in 23 kidneys; N: (+), N+E: (−) | 3 lesions in 2 kidneys; N: (−), N+E: (+) |
| (E) − (N+E) | 21 kidneys | 25 lesions in 10 kidneys; E: (+), N+E: (−) | 21 lesions in 11 kidneys; E: (−), N+E: (+) |
| (N) − (E) | 15 kidneys | 55 lesions in 22 kidneys; N: (+), E: (−) | 4 lesions in 3 kidneys; N: (−), E: (+) |

N: nephrographic phase, E: excretory phase, (+) detected, (−) not detected.

were concordant in 21 kidneys. In 10 kidneys, 25 lesions (1–6 lesions in one kidney) were detected in E phase group, but not in N+E phase group. On the other hand, in 11 kidneys, 21 lesions (1–4 lesions in one kidney) were detected in N+E phase group, but not in E phase group. When N phase group was compared with E phase, the results were concordant in 15 kidneys. In 22 kidneys, 55 lesions (1–8 lesions in one kidney) were detected in N phase group, but not in E phase group. On the other hand, in 3 kidneys, 4 lesions (1–2 lesions in one kidney) were detected in E phase group, but not in N phase group. These findings were summarized in Table 1.

In statistical analysis, for the lesions which were >5 mm, all three intraclass correlations were concordant ($r=1$).

For the lesions which were ≤5 mm, intraclass correlation calculated for each group was found to be important statistically (N phase − N phase + E phase: $r=.8374$, 95% CI [0.7134, 0.9106]; E phase − N phase + E phase: $r=.7388$, 95% CI [0.5576, 0.8528]; N phase − E phase: $r=.7192$, 95% CI [0.5281, 0.8409], $P=.0000$). When the calculated intraclass correlations were compared with each other, the difference was not found to be important.

The first two radiologists decided that the N phase images were better in 15 patients (75%) for radiological image quality and radiological self-confidence, while the E phase images were better in 1 patient (5%). In 4 patients (20%), no difference was detected.

In nine examinations (45%), streak artifacts were detected in E phase images; misinterpretation due to these artifacts was not detected.

## 4. Discussion

Renal cell carcinoma is the most common primary malignancy of the kidney. In recent years, the incidence of the renal cell carcinoma has increased steadily; however, therapeutic techniques have led to little improvement. In spite of these facts, the improving survival rates are thought to be resulted from the incidental diagnosis of not only renal cell carcinoma but also other renal mass lesions with the aid of radiological techniques. Helical CT is one of the most important of these techniques, which is used for detection, characterization and, if necessary, surgical planning of renal mass lesions [2,5].

Helical CT can image the kidneys during three different phases after intravenous contrast injection. During the corticomedullary phase, which occurs between 25 and 80 s after the initiation of contrast injection, much of the contrast material resides within the vascular system, including the renal cortical capillaries. The renal cortex enhances from its unenhanced attenuation of 30–40 to 145–185 HU; medullary enhancement is minimal (60–90 HU). Difference in enhancement between the cortex and the medulla and unopacification of the collecting system decrease the sensitivity of the corticomedullary phase in detecting mass lesions. The N phase begins 85–120 s after initiation of contrast injection. During this phase, contrast material filters through the glomeruli enters the loop of Henle and collecting ducts; renal medullary enhancement becomes similar to renal cortical enhancement (on average, between 120 and 170 HU), making this phase convenient for lesion detection. The E phase occurs approximately 3–5 min after contrast injection begins. The plasma concentration of contrast material declines as a result of excretion into the collecting system and diffusion into extracellular spaces, so that parenchymal enhancement, remaining homogenous, gradually decreases over time [1,6].

In this study, there were not any lesions except for cysts of category 1 or 2 according to Bosniak classification and angiomyolipomas/lipomas. But, since almost all of the renal mass lesions appear hypodense to the normal parenchyma in delayed images [1], these lesions can be accepted as a model for the other masses, especially for the malignant ones.

The results for the lesions >5 mm were completely concordant in all three groups. However, a discrepancy was realized between the groups for the lesions ≤5 mm. This discrepancy was thought to be unimportant practically because some of these "tiny" lesions are believed to be probable cysts though they cannot be characterized because of their size, whereas others are thought to be pseudolesions due to inhomogenous nephrograms, collecting system abnormalities and focal cortical defects. Interobserver variations are inevitable in detection of these lesions, since the diagnostic criteria are subjective. Some authors suggested that detection of these lesions leads to recommendations for follow-up imaging studies causing unnecessary patient anxiety [1,7]. Besides, in this study, the differences between three groups in detecting tiny lesions were not statistically significant.

These results showed us that, in the detection of renal mass lesions, whether >5 or ≤5 mm, obtaining N and E phases, together, are not essential; one of these phases can be selected in respect of other advantages or disadvantages.

The dense and homogenous parenchymal enhancement is an important feature of the N phase images. In this study, there were few lesions that could not be detected in N phase, but were detected in the other groups. All of these lesions were ≤5 mm. Moreover, in 75% of patients, N phase images were found to be superior to E phase images for radiological image quality and radiological self-confidence. In the recent studies, N phase images were found to be aesthetically superior to E phase images, as well [4]. These findings can be accepted as the advantages of the dense and homogenous parenchymal enhancement of the N phase. On the other hand, there were so many ≤5-mm lesions detected only in N phase, but not in the other groups, for which the possibility of false positive results could not be neglected. From this perspective, the dense and homogenous parenchymal enhancement can be thought to be a disadvantage related to the N phase.

The contrast material in the collecting systems is an absolute advantage of E phase, which makes the diagnosis easy for the lesions in or adjacent to the collecting systems. In our study, four parapelvic cysts, which were >10 mm, were detected in all three groups; no mass lesion in the collecting systems was present. One potential problem related to E phase is streak artifacts from concentrated contrast material in the collecting systems [1,3,8]. These artifacts were speculated to be more likely to occur when nonionic contrast material was used, because nonionic contrast agents produce less osmotic diuresis and thereby excreted in higher concentrations than ionic contrast agents. In the study of Yuh et al. [3], in only one of 39 examinations, the streak artifacts were thought to limit the assessment of the renal parenchyma and to interfere with the detection of a renal mass. In this study, in 45% of examinations, streak artifacts were detected. However, misinterpretation due to these artifacts was not noted.

To our knowledge, only one study has compared the reliability of N phase images in detecting renal mass lesions with that of E phase images. In that study, it was suggested that the discrepancy between N and E phases in detecting lesions was almost entirely related to ≤5-mm lesions and the failure to detect them would have had no impact on patient care [3]. In our study, N + E phase group was planned as a distinct group, different from the study of Yuh et al., but no statistically significant difference was found between three groups in detecting lesions. The results of two studies were similar. In the same study, no significant difference was seen between N and E phase images in characterizing lesions, although N phase images were preferred aesthetically to E phase images. In addition, collecting system-related abnormalities were found to be characterized better on E phase images, so E phase images were recommended [3]. In our study, only lesion detection was intended, characterization was not attempted since there was not a wide variety of lesions.

In conclusion, since two-thirds of cases of renal cell carcinoma occurred in patients for whom the diagnosis was not clinically suspected [2], performing a routine abdominal CT examination with delayed renal images may be required for optimal lesion detection. N phase, E phase and N + E phase groups are not different from or superior to each other in lesion detection. E phase images are appropriate in detection of lesions in or adjacent to collecting systems, whereas N phase images are more aesthetic and reliable subjectively.

In our opinion, obtaining delayed renal images in 3–4 min after the initiation of contrast injection not only decreases the radiation exposure and minimizes the probability of missing a renal mass, but also includes the affirmative features of both N and E phases; thus, can represent the delayed phase in detecting renal mass lesions.

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