The unenhanced spiral CT has been used to evaluate patients with acute flank pain popularly in the United States for many years. We performed this study to reassess the value and limitation of the plain KUB film in comparison with the unenhanced spiral CT in 101 patients with acute flank pain.

We obtained a sensitivity of 63% and 98% for diagnosing urinary stones by the plain abdominal radiography and the unenhanced spiral CT respectively. About one-third of the stones depicted by the unenhanced CT were not able to be demonstrated on the plain radiographs in our patients. In the presence of secondary signs of ureteric obstruction including ureteric dilatation, it is still possible to differentiate stones from phleboliths in pelvic cavity on the unenhanced CT.

We confirm that the plain radiography is of less value in evaluation of patients with acute flank pain caused by urolithiasis in comparison with the unenhanced spiral CT. We recommend the unenhanced spiral CT as a method of choice to assess the patients with acute flank pain when the results of physical examination and plain KUB film are inconclusive or suspicions for urolithiasis, and when the IVP is contraindicated to the patient or the patient hesitate to receive such a study.

Keywords: Acute flank pain; CT, Unenhanced, Spiral; Radiography, Plain; Urinary stone.
popularly in the patients with acute flank pain who were referred for imaging evaluation in the United States for many years. Some hospitals also use it as the only screening modality in the emergency department [7-13]. To reassess the value and limitation of plain KUB film in the patients with acute flank pain and to compare those of the unenhanced spiral CT, we evaluate the diagnostic capabilities in detecting urinary stones on the plain abdominal radiography and the unenhanced spiral CT in 101 patients. The pitfall of the unenhanced spiral CT in the evaluation of urinary stone and the controversy in the application of the unenhanced spiral CT in patient with acute flank pain are also discussed.

MATERIALS AND METHODS

From July to December 1999, 101 patients with acute flank pain were randomly arranged to undergo the unenhanced spiral CT of the abdomen from the patient lists of intravenous pyelography (IVP). They were all referred for IVP due to acute flank pain. The non-contrast CT was performed immediately after the control plain KUB film in IVP studies had been taken and prior to contrast medium administration. The study group comprised 67 men and 34 women with the age of 28-78 years (mean 46 years old).

All CT examinations were performed with a HiSpeed Advantage CTi scanner (General Electric, Milwaukee, Wisconsin, USA). Images were obtained from the top of the kidneys to the bladder base. For virtually all patients, the imaging data were acquired with the spiral mode at a 5-mm-thickness section and a pitch of 1:1, and in clusters of 15-20 sections obtained during a breathhold. The exposure parameters were 120kVp, 270 mA and total exposure time were 68 seconds.

Retrospective reviewing of all plain KUB film and the unenhanced CT images were done by two of the authors (J.C.M. & K.C.H.) simultaneously and a consensus opinion was obtained for all findings. All studies were evaluated for the presence or absence of urinary stone in both right and left urinary tracts. We considered a positive finding for the urinary stones as a calcification density was identified in the lumens of the urinary tracts. The locations of urinary stones and their sizes were recorded for each patient. Interpretations of all images were recorded as “positive” (as urinary stone are present) or “negative” (in the absence of urinary stones).

The final results of all patients were determined by the IVP studies performed on the same day after the unenhanced spiral CT.

For the comparison of the sensitivity and specificity of the plain radiography and the unenhanced spiral CT in detection of urinary stones, Chi square test was used to analyze the results. A p-value of less than 0.05 was considered to indicate a statistically significant difference.

RESULTS

As shown in table 1 and table 2, among 101 patients in our study, KUB depicted 76 urinary stones in 56 patients, including 44 stones on the right side and 32 stones on the left side. True negative finding was noted in 26 patients. KUB failed to demonstrate stones in 47 patients. Phleboliths were mistake as distal ureteric stones in 7 patients. In contrast the unenhanced CT scans showed 121 urinary stones in 70 patients including 60 stones on the right side and 61 on the left side. Negative findings were noted in 31 patients and two phleboliths were mistaken as distal ureteric stones and two distal ureteric stones were mistaken as phleboliths. As shown in table 1, 35 right-sided renal stones (Figure 1a,b), 31 left-sided renal stones (Figure 2a,b), 25 right-sided ureteric stones and 30 left-sided ureteric stones (Figure 1a,c) were found by using the unenhanced spiral CT. Seventeen patients had more than 1 renal stones, five patients had more than 1 ureteric stones. Concurrent right-sided and left-sided renal stones were found in 8 patients, and concurrent renal and ureteric stones were

<table>
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<th>Imaging modalities</th>
<th>Sites of Stone</th>
<th>Upper Kidney</th>
<th>Mid</th>
<th>Lower</th>
<th>Proximal</th>
<th>Ureter Mid</th>
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<td>11</td>
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<td>3</td>
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<tr>
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<td>14</td>
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<td>3</td>
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<td>3</td>
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found in 15 patients (Figure 1b, c).

A sensitivity of 63% and a specificity of 80% for diagnosing urinary stones by the plain abdominal radiography, and a sensitivity of 98% and a specificity of 94% for diagnosing urinary stones by the unenhanced spiral CT were found. Such differences in the sensitivity and the specificity were statistically significant.

The average size of the urinary stones identified on the plain radiographs were 4.5 mm (range, 2 to 20 mm) and that of those not visualized on the plain radiographs was 3 mm (range, 2-9 mm), respectively. The average size of urinary stones identified on the CT were 2.3 mm (range 1 to 20 mm).

The unenhanced CT scans identified 13 left-sided hydronephrosis (Figure 1b), 15 left-sided hydroureter (Figure 1c) as well as 10 right-sided hydronephrosis and 13 right-sided hydroureter. No evidence of calcified shadows could be detected in 3 cases with right-sided hydronephrosis and hydroureter, and in 2 cases with left-sided hydronephrosis and hydroureter.

The mistakes in diagnosing 2 phleboliths as distal ureteric stones and 2 distal ureteric stones as phleboliths by the unenhanced CT scans were all confirmed with IVP.

The unenhanced CT findings also identified other abnormalities unrelated to urolithiasis in 9 patients, which included 5 gallstones (Figure 3a, b), 2 uterine fibroids, one hypoplastic right kidney (Figure 2c) and one bladder tumor (Figure 3c). These diagnoses were confirmed by additional imaging studies including IVP, sonography, and clinical follow up.

**DISCUSSION**

Acute flank pain is one of the most common complaints of the patients at the emergency room. A wide variety of urinary and other diseases can cause acute flank pain, but renal colic caused by urolithiasis is always first considered in the differential diagnoses.

The sensitivities of the detection of urinary stones on the plain radiographs reported by Roth et al [14] in 1985 and Mutgi et al [15] in 1991 were 62% and 58% respectively. Many ureteric

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**Figure 1.** A 44-year-old man with concurrent right-sided renal stone and left-sided ureteric stone. a. KUB showed a calcified spot in the right upper quadrant of the abdomen (upper arrow) and left upper aspect of the pelvis (lower arrow). b. The unenhanced spiral CT at renal level showed a 0.5 cm renal stone (arrow) and marked contralateral hydronephrosis (H). c. The unenhanced spiral CT at pelvic region showed a 0.4 cm left-sided ureteric stone associated with dilation of the ureter (arrow).
Figure 2. A 53-year-old man with left-sided renal stone. **a.** KUB did not show the stone. **b.** The unenhanced spiral CT showed a 0.2 cm left renal stone (arrow). **c.** The unenhanced spiral CT at 2 cm above b showed mild left pyelocaliectasis (arrow) and a hypoplastic right kidney (white arrowhead).

Figure 3. A 78-year-old man had a gallstone and a bladder tumor. **a.** KUB showed a calcified density at right subhepatic area (arrowhead). **b.** The unenhanced spiral CT showed a 2 cm gallstone (arrowhead). **c.** The unenhanced spiral CT at pelvic region showed a 2 cm polypoid mass at left posterior aspect of the urinary bladder which had been proved to be a bladder carcinoma (arrowhead).
stones cannot be identified on the plain KUB film in our daily practices; consequently, IVP or even retrograde pyelography are eventually needed to detect these stones. The unenhanced spiral CT is widely accepted as a screening tool for the assessment of acute flank pain in the emergency department in United States since the reports of Smith et al and Sommer et al [1,2]. Smith et al [11] and Dalrymple et al [7] found CT had 96-97% sensitivity, 96-99% specificity and 97-98% accuracy for diagnosing ureteric stone disease. The unenhanced spiral CT is capable of detecting virtually all ureteric calculi regardless of composition [6-10].

Several recent investigations indicated that the unenhanced spiral CT was indispensable not only in screening but also in helping to address plans for stone removal [13]. The urologists also accepted such imaging modality as a useful tool in both screening and aiding in the determination of surgical intervention [2-4].

In our study, the plain abdominal radiographs and the unenhanced spiral CT were obtained in patients with acute flank pain selected randomly from a group of patients referred for IVP. As a result, there is no possibility of selection bias in our study. As shown in table 1 and table 2, KUB depicted 76 true urinary stones whereas the unenhanced CT depicted 121 true urinary stones in 101 patients. The sensitivity for diagnosing urinary stones by plain abdominal radiography and the unenhanced spiral CT are 63% and 98% respectively. Such difference is statistically significant.

Our results were similar to those reported by others [1-3,7,14,15]. About one-third of the stones depicted by the unenhanced CT could not be shown on the plain radiographs in our patients. Our study confirmed that the plain abdominal radiography is of limited value in evaluation of patients with acute flank pain due to urolithiasis in comparison with the unenhanced spiral CT.

The average size of the urinary stones identified on the plain radiographs and the unenhanced spiral CT were 4.5 mm and 2.3 mm, respectively. The mean size of urinary stones not visualized on the plain radiograph was 3 mm (range, 2-9 mm). CT can demonstrate stones smaller in size in comparison with the plain radiographs. All stones are virtually visible on CT regardless of the composition of the urinary stones. They have significantly higher CT attenuation values than the surrounding soft tissue [6,7]. CT is able to confirm the nature, the precise size and the location of individual calculous masses seen on the plain radiographs [7].

In our study, the unenhanced CT scans identified 10 right-sided hydronephrosis and 13 right-sided hydroureter, as well as 13 left-sided hydronephrosis and 15 left-sided hydroureter. In addition, one patient had hypoplastic kidney and one had a bladder tumor, which did not show up on the plain radiographs. Therefore, the unenhanced CT is also capable of identifying certain other causes of acute flank pain in addition to urinary stone disease. A total of 7 patients had abnormalities unrelated to the urinary tract including 5 with gallstones and 2 with uterine fibroids. The lesions were all demonstrated more definitely with the unenhanced CT than the plain abdominal radiograph.

In our series, two false positive findings of mis-identifying the phleboliths as distal ureteric stones and two false negative findings of mis-diagnosing distal ureteric stones as phleboliths by the unenhanced CT were noted. Such results were major shortcomings of the unenhanced spiral CT since phleboliths can often be seen along the normal anatomical territory of the ureter especially within the pelvis mimicking the
ureteric stones [6]. A careful differentiation of all small opaque shadows in pelvic cavity is particular important in order to prevent the diagnostic pitfalls. However, in the presence of the secondary signs of ureteric obstruction such as ureteric dilatation (Figure 1c), it is still possible to differentiate stone from phlebolith on the unenhanced CT.

The cost of a plain KUB film reimbursed by the Bureau of the National Health Insurance is NTD 200, while the cost of a non-contrast CT study is NTD 3800 at present. A great discrepancy exists between the payments for these two studies. Though the unenhanced spiral CT is a useful tool in depicting urinary stones based on its extremely high sensitivity and specificity, it is not feasible to order a CT for all patients with acute flank pain in our routine practice instead of ordering a routine KUB film [7-13]. However, it is worth recommending the unenhanced spiral CT as a method of choice to assess the patients with acute flank pain when the results of physical examination and plain KUB film are inconclusive or suspicions of urolithiasis, and when the IVP is contraindicated or refused by the patient.

REFERENCES

急性腰痛患者的泌尿道結石：腹部X光素片與無對比增強螺旋CT的比較

鄭慶明 孔慶惠 王永成 吳昭瑩 李玟瑜 范君凱 黃永堅

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多年來無對比增強螺旋CT已在美國成為評估急性腰痛患者的常用檢查。本研究主要是針對101名發生急性腰痛的患者以無對比增強螺旋CT作比較，重新評估KUB X光素片的價值和限制。

本研究發現以X光素片和無對比增強螺旋CT排查泌尿道結石的敏感度各為63%和98%，亦即大約有三分之一的結石無法在X光素片中顯現，經由輸尿管擴大的失級病徵也可能在無對比增強CT中區別靜脈石和結石。

本研究再度證實X光素片和無對比增強螺旋CT相比，它在評估急性腰痛方面的價值有所限制。當患者經過體檢和X光素片檢查之後無法獲得診斷，而患者又對IVP有禁忌或患者遲疑不願接受檢查時，無對比增強螺旋CT是值得考慮的評估方法。

關鍵詞：急性腰痛；電腦斷層，無對比增強；螺旋型；放射線攝影，素片；泌尿道結石