



Comparison Between Intravenous Urography and Computed Tomography Urography in Diagnosing Ureteropelvic Junction Obstruction

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ABSTRACT

Background: Ureteropelvic junction obstruction (UPJO) is mostly a benign, congenital condition that remains an enigma in terms of diagnosis. Despite several advances in morphological and functional imaging of UPJO, controversies still remain about the optimal imaging method to diagnose UPJO. Intravenous urography (IVU) has been standardized and is a familiar technique to urologists, however, its diagnostic efficacy is not high and thus another examination is usually needed.

Objectives: The aim of this study was to compare CTU and IVU in the assessment of patients with UPJO.

Patients and Methods: Sixty-one patients with final diagnosis of UPJO received both IVU and CTU before operation. The CTU examination included three phase axial scan: non-contrast (phase I), nephrographic phase (phase II), excretory phase (phase III) and CTU images were obtained by coronal reconstruction of phase I and III. Two radiologists who were unaware of the findings independently interpreted these examinations. The diagnosis of both imaging studies were compared with the final diagnosis and the two examinations were compared by the results of diagnostic accuracy for different causes of disease.

Results: In our study, the cause of UPJO were mainly crossing vessel, stone disease, carcinoma, fiber cord compression, congenital distorted uretero-pelvic junction, inflammatory stenosis, high ureteropelvic junction, ureteral valves and renal duplication combined with obstruction. The diagnostic accuracy is 85.2% in CTU and 49.2% in IVU. Although suspicious abnormal findings in IVU were recognized in many patients (23/61), they were usually inadequate for making accurate diagnosis and further examinations were thus acquired. As compared with IVU, the operative procedure of CTU was simpler and the examination time was shorter, however, the cost and the radiation exposure was larger.

Conclusions: CTU has higher diagnostic efficacy as compared with IVU and could be the one-stop examination for patient with UPJO. It should be under consideration to have CTU as the first line diagnostic tool, although more delicate cost-effectiveness evaluation is needed for conclusion.

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► Implication for health policy/practice/research/medical education:

This article suggests that CTU has higher diagnostic efficacy as compared with IVU and could be the one-stop examination for patient with UPJO.

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1. Background

Ureteropelvic junction obstruction (UPJO) is mostly a benign, congenital condition that remains an enigma in terms of diagnosis (1). The etiology of UPJO can be due to muscular abnormalities of the ureter, ureteral polyps, ureteral folds, crossing vessels, or secondary to vesicoureteral reflux (2). Although many advances in morphological and functional imaging of UPJO have been made, controversies still remain surrounding the optimal imaging method to diagnose UPJO (3, 4). However, there is no doubt that a precise anatomic assessment of the renal parenchyma, collecting system, and vascular pedicle is fundamental to the surgical management, providing insight into the condition for each individual patient. Intravenous urography (IVU) has long been widely used for the evaluation of UPJO, and it is now still the first line diagnostic tool in China and several other countries. It has been standardized and familiar to urologists, however, its diagnostic efficacy is not high and thus other examination is usually needed.

In recent years, Computed tomography urography (CTU) has become a powerful tool in assessing the entire urinary tract (5-7). As compared with IVU, CTU has been documented to have not only much higher accuracy, but also other advantages, such as the operative procedure is simple, the examination time is comparatively shorter and the patients usually do not feel uncomfortable during the operation. With improved scanning speed and resolution, the collecting system could also be demonstrated with the coronal plane imaging by reconstructing secretory phase image by MPR technique. Even though, it is still under debate if IVU should be replaced by CTU when considering the higher price and larger radiation exposure (8, 9).

2. Objectives

In this study, we compared the accuracy of IVU and CTU in the diagnosis for UPJO, and to design the most proper scanning protocol for CTU.

3. Patients and Methods

3.1. Study Population

Between October 2007 and January 2010, 61 consecutive patients (34 female patients and 27 male patients) with a mean age of 42 years (ranged from 18 to 71 years) were entered into our study. Final diagnosis of all these patients was UPJO, which was according to operation findings. Those who were not suitable for intravenous administration of iodine containing contrast medium because of pregnancy, impaired renal function or allergic history were not recruited in our study. Every patient underwent both IVU and CTU before operation; the interval between the two examinations was 2-3 days. This is a retrospective study, and the study was approved by the ethical review board.

3.2. Operative Procedure of IVU

Our IVU protocol included a bowel preparation with folium cassia the day before examination. At the beginning of the examination, KUB (the plain of kidney, ureter, bladder) was taken, and then 40 mL of contrast agent (60% Meglucamine Diatrizoate) was administered, the patient's abdomen was pressed for 15 min, contrast tomograms were performed 7, 15, 30 minutes after the contrast agent was transfused. Oblique and post-void images were obtained as needed. Larger doses of contrast agent (around 80 mL) were used in patients who had bad quality images, and then images were again obtained 60-120 minutes later.

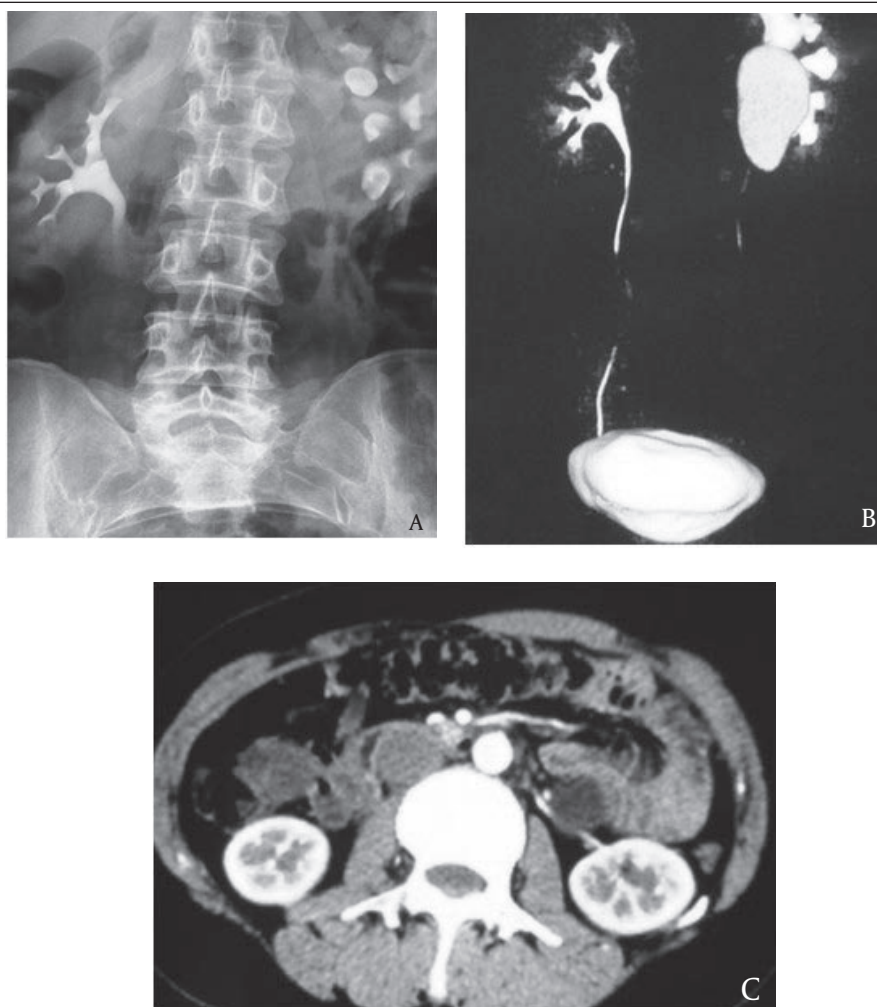
3.3. Operative Procedure of CTU

Our CTU protocol was performed without oral contrast or bowel preparation. The computed tomography used in this study was LightVCT64-slice helical CT (GE Healthcare). 5×1.25mm collimation/pitch 6, reconstructed axial scan of 5mm thickness were obtained. The scanning range was from kidney to urinary bladder. Phase I began with a noncontrast CT. Phase II (nephrographic phase) began 120 seconds after intravenous administration of contrast agent iohexol (Omnipaque) (Naiming Pharmaceuticals Limited, Shanghai, China) with the density of 300 mg/mL, the dosage of 1.5 mL/kg and the inject velocity of 3 mL/s. Phase III (excretory phase) began 6-8 minutes after intravenous contrast was administered. CTU images

Table 1. Comparison Between IVU and CTU in Diagnosis of UPJO

Urologic Abnormalities	IVU ^a , No. (%)	CTU ^a , No. (%)	P value
Crossing vessel, n=11	6 (54.5)	9 (81.8)	<i>P</i> < 0.01
Stone disease, n=6	3 (50)	5 (83.3)	<i>P</i> < 0.01
Carcinoma, n=6	3 (50)	6 (100)	<i>P</i> < 0.01
Fiber cord compression, n=9	4 (44.4)	7 (77.8)	<i>P</i> < 0.01
Congenital distorted ureteropelvic junction, n=14	9 (64.3)	12 (85.7)	<i>P</i> < 0.01
High ureteropelvic junction, n=4	1 (25)	4 (100)	<i>P</i> < 0.01
Others, n=11	4 (36.7)	9 (81.8)	<i>P</i> < 0.01
Total, n=61	30 (49.2)	52 (85.2)	<i>P</i> < 0.01

^a Abbreviations: CTU, Computed tomography urography; IVU, Intravenous urography

Figure 1. Detection of the Ventral Crossing Artery at the Ureteropelvic Junction by Axial Ctu Image.

UPJO in a 24-year-old patient. (A) Distal obstructive ureter was not displayed by IVU image. (B) Oblique reconstructed imaging of CTU images showed left side hydronephrosis and distal obstructive ureter. (C)

were obtained by coronal reconstruction of phase I and III images of 5 mm thickness by the 3D work station. For those who developed a delayed image because of urinary obstruction, another scan was taken 30 minutes after intravenous contrast was administered. Both IVU and CTU images were interpreted by two experienced urologists independently who were blind to the clinical history, diagnosis and the results of other imaging examinations. The diagnosis of both imaging studies were divided into 3 groups which included accurate diagnosis, suspicious lesion but no definite diagnosis and no specific finding. Both the results were compared with the final diagnosis.

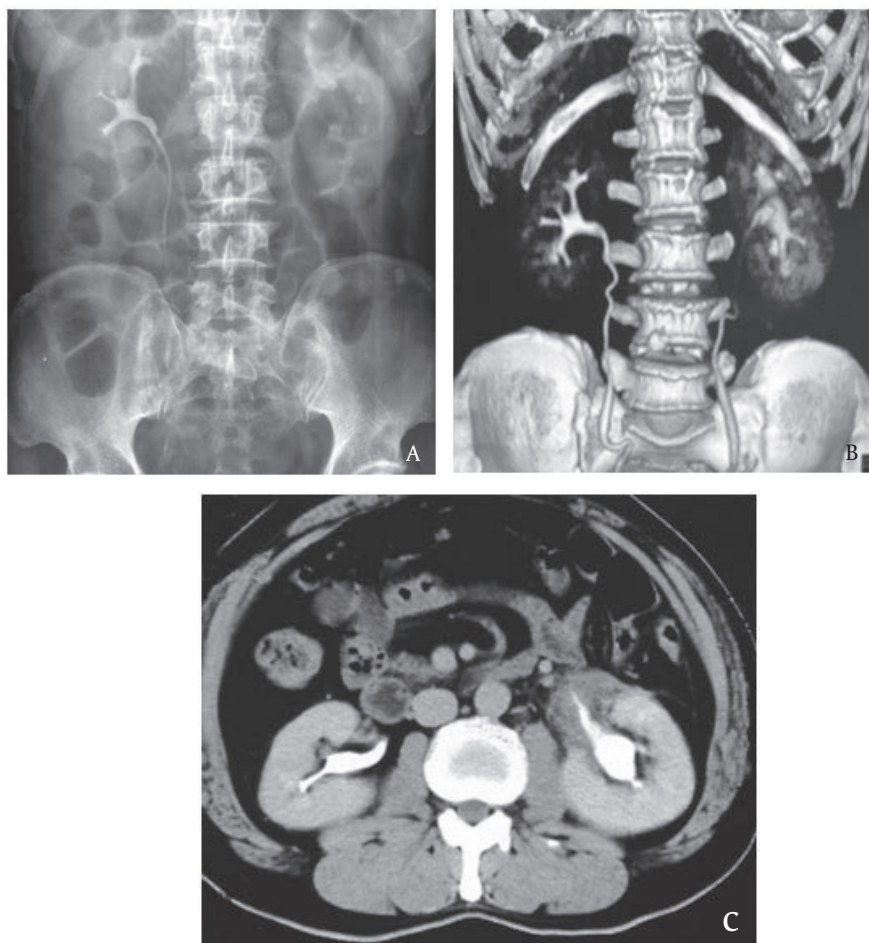
3.4. Data Analysis

The data obtained from CTU were compared with those from IVU in terms of diagnostic rate. Chi-square test was used to analyze the data, and sensitivities for each method were also calculated.

4. Results

During October 2007 to January 2010, a total of 83 patients were referred from urologic clinic for imaging study. All patients were diagnosed with UPJO according to operation findings. After excluding those who received only either IVU or CTU study and those with the interval between both examinations more than 90 days, a total of 61 patients were recruited in our study. Among those patients, thirty-two had a right-sided UPJO and 29 patients had a left-sided UPJO. The diagnostic accuracy of CTU for UPJO in our study was 85.2%, which was significantly higher than the 49.2% of IVU. Although suspicious abnormal findings in IVU were recognized in many patients (23/61), they were usually inadequate for making accurate diagnosis and further examinations were thus acquired.

Crossing vessels were detected in 9 patients in CTU study and therefore diagnosis could be made, however, only nephredema could be displayed in 6 of those

Figure 2. Axial Ctu Image Shows Large Tumor in Left Renal Pelvis.

UPJO in a 63-year-old-patient. (A) The left side collecting system could not be demonstrated by IVU image. (B) Oblique reconstructed imaging of CTU images showed left side hydronephrosis and stenosis of the left ureter. (C)

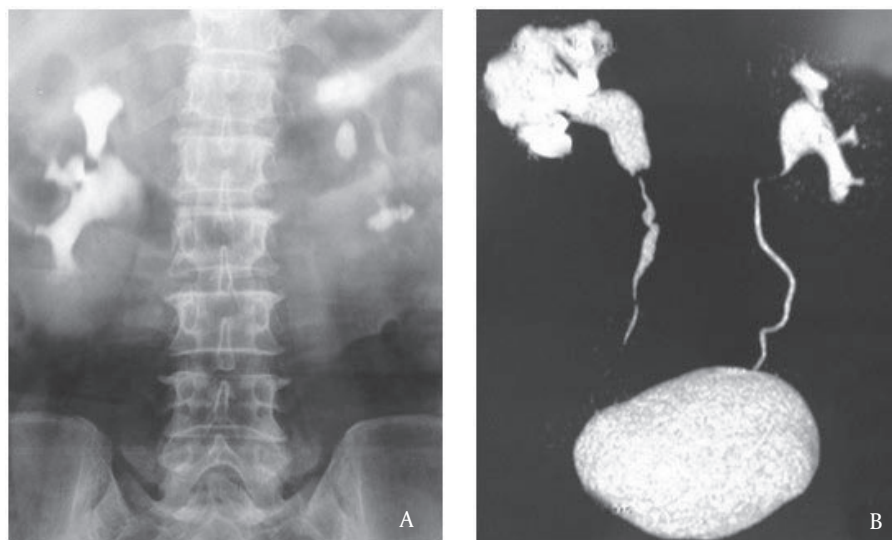
patients in IVU and the location of stenosis and distal ureter could not be displayed (*Figure 1*). Five acquired cases were diagnosed resulting from stone disease in CTU study. Among those patients, urolithiasis had been detected only in 3 patients in IVU study. It failed to detect most often because of radiolucent stone. In the 6 cases of carcinoma, CTU could obtain accurate diagnosis in all cases by noncontrast (phase I) and nephrographic phase (phase II) images. The excretory phase (phase III) images could delineate the range of the tumor more clearly and the relationship of the tumor with uretero-pelvic junction could be defined (*Figure 2*). In the 9 cases of fiber cord compression, CTU could obtain accurate diagnosis in 7 cases; however, IVU could only obtain diagnosis in 4 cases. Twelve cases were diagnosed as congenital distorted uretero-pelvic junction in CTU compared with 9 cases in IVU. Others such as inflammatory stenosis, high uretero-pelvic junction, ureteral valves, and renal duplication combined with obstruction were also diagnosed. There were significant differences ($P < 0.01$) for the diagnostic accuracy when compared IVU with CTU (*Table 1*).

IVU study took 25-120 minutes with a mean time of 67.1 ± 26.7 minutes and CTU study took 10-30 minutes with a

mean time of 18.9 ± 8.4 minutes. There was a significant difference between them ($P < 0.01$). The visualization rate of the affected side and/or distal end beyond the obstruction of CTU and IVU were 90.2% (55/61) and 39.3% (24/61) respectively, with a significant difference ($P < 0.01$) (*Figure 3*). Three patients, who failed to display in both IVU and CTU study, underwent retrograde pyelography (RP) to display distal urinary tract beyond the obstruction.

5. Discussions

The choice of procedure for treating UPJO depends on many factors, including renal function, the degree of hydronephrosis, the length of the stenotic segment, and the presence of crossing vessels (10). Therefore, whether the imaging study could provide enough information is important for treatment options and may influence selective management choices of retrograde endopyelotomy or surgical dismembered pyeloplasty (either open or laparoscopic) (11-13). IVU has been widely used in diagnosing urological disease (14). We could observe the integral configuration of the urinary system in IVU as it could also show the diseased region, the extent

Figure 3. Diseased Region and Distal Obstructive Ureter Were Displayed by Ctu Image.

UPJO in a 38-year-old patient. (A) Right side nephrydrosis were displayed, however, obstruction and right ureter cannot be displayed by IVU image. (B)

of dilation and hydrops of the renal pelvis and ureter, and reflect the damage of renal function. However, there are some disadvantages of IVU. First, the bowel preparation was necessary. If the bowel preparation was not done well, the quality of the image would be poor and misdiagnosis could occur easily. Second, the patient might feel uncomfortable when their abdomen is pressed during the IVU examination. Third, the diseased urinary tract might not show in some patients due to obstruction, because the efferent of the kidney are blocked or the renal function was damaged. Further examinations, such as RP, are needed in those cases.

Fourth, IVU can only show the diseased region in the collective system, ureter and bladder. If the collective system has not been compressed by the diseased renal parenchyma, it will not be shown in IVU. If the collective system has been compressed, IVU only shows its outline, it cannot provide sufficient evidence to make accurate diagnosis. Dalla Palma thought that many diseases of the upper urinary tract including UPJO may be ignored if we only depend on IVU examination (15). If the distal urinary tract beyond the diseased region could not be shown, it suggested the presence of obstruction, which was meaningful for the treatment (16, 17). The distal urinary tract beyond the diseased region sometimes could not be shown in IVU because of the intestinal gas, low density resolution or damaged renal functions. At that time, RP is always recommended. However, RP is such an invasive examination that some patients cannot endure. The density resolution of CTU is higher than routine X-ray, as long as the contrast agent could pass the diseased region, the distal urinary tract could be shown in CTU. Kawamoto suggested that the CTU could not only show the obstructive ureter, but also revealed the location and the cause of the obstruction (18). El-Nahas reported that the distal ureter beyond the obstruction, which is not

shown in IVU, could be seen in CTU in a group of 42 UPJO patients (19). In our study, the visualization rate of the distal ureter beyond the obstruction on CTU was 90.2 %, which was much higher than 39.3% of IVU. Except for some of the patients with complete obstruction, CTU could display most of the urinary tract beyond obstruction.

It is reported that the success rates of endopyelotomy for UPJO can drop significantly in the presence of crossing vessels (20, 21). Therefore, CTU could help us to choose the better surgical procedure because crossing vessels could be detected in CTU. For some patients with tumor, CTU not only showed the integral urinary tract and filling defect of the tumor, but the CT image could also reflect the location and gross morphological characteristics of the tumor, as well as the status of the surrounding tissue, which could avoid us to conjecture the diagnosis indirectly by the filling defect displayed in IVU. A further advantage of CTU in UPJO is that the integrity, morphology, and perfusion of the renal parenchyma can be evaluated in addition to obtaining information on the spatial orientation of the vessels and the presence of calculous disease. It has been suggested that CTU should be considered as a routine examination for the UPJO patients before operation (19). The sensitivity of CTU to discover the cause of the obstruction has been found to be 100%, which was much higher than 74% of IVU in a group of chronic obstructive urinary disease patients (22). Besides, intestinal gas did not affect the quality of CT image in most of the cases, thus it was not necessary to make bowel preparations. Pressing the patients' abdomen was not needed as well during the procedure. Thus, it was comparatively safe for the geriatric patients whose general conditions were not good and for patients who had abdominal diseases, such as abdominal aneurysm. The operative time of CTU was much shorter than that of IVU, which improved the safety as well. In recent years,

due to the widespread installation of multidetector CT machines, some radiology departments had stopped doing routine IVU's and started doing CTU instead in some hospitals. However, IVU is still quite widely utilized in most hospitals in China and several other countries, and it is under debate whether IVU should be replaced by CTU. Although CTU has higher radiation dose and cost, it does provide more information than IVU and could be the one-stop examination for patient with UPJO. CTU now has an established body of evidence to support its use across a range of clinical scenarios and the inherent advantages of CT in terms of 3D spatial relationships etc is obvious and without question. Modern CT machines can now offer sub-millimeter spatial resolution which is adequate for the detection of even minor urothelial abnormalities. Concerning the high percentage of true pathological findings among the patients with UPJO in our study, it should be under consideration to have CTU as first line diagnostic tool, although more delicate cost-effectiveness evaluation is needed for conclusion. CTU has higher diagnostic efficacy for UPJO as compared with IVU and could be the one-stop examination for patient with UPJO.

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Conflict of interest

All authors were employed by the Department of Urology, Zhongshan Hospital, Fudan University.

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