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KIDNEY DISEASE

Diagnostic Efficacy and Imaging Characteristics of MRI Combined with CT in Children with Duplex Kidney

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Keywords. duplication of kidney, MRI, CT, diagnostic performance, imaging characteristics

Introduction. To analyze the diagnostic efficacy and imaging characteristics of MRI combined with CT in children with duplication of kidney.

Methods. A retrospective analysis was conducted of the clinical data of 40 children with duplication of kidney admitted to our hospital between January 2019 and January 2024 and confirmed surgically. All patients underwent MRI and CT examinations, with surgery as the gold standard. The diagnostic efficacy of MRI and CT in children with duplication of kidney was analyzed.

Results. CT confirmed 32 cases of duplication of kidney, with a diagnostic rate of 80%. MRI confirmed 33 cases of duplication of kidney, with a diagnostic rate of 82.50%. CT combined with MRI confirmed 39 cases of duplication of kidney, with a diagnostic rate of 97.50%. The diagnostic rate of CT combined with MRI for duplication of kidney was higher than that of CT or MRI alone ($P < .05$). The diagnostic accuracy of CT combined with MRI for hydronephrosis duplication was 100%, significantly higher than the 77.27 and 81.82% rates of CT and MRI alone ($P < .05$) . There was no significant difference in the diagnostic accuracy of CT or MRI alone for developmental and dysplastic duplication ($P > .05$).

Conclusions. MRI combined with CT has a high diagnostic efficacy for duplex kidney and its classification in children, which can provide a reference for clinical diagnosis and treatment and can be vigorously promoted in clinical practice.

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INRODUCTION

Duplicated kidney is a common congenital urinary malformation in children. It refers to the presence of two renal segments and two collecting systems within one renal capsule.[1] It can cause urinary tract infection, hydronephrosis, renal insufficiency and other hazards, seriously affecting the health of the child.[2] At the same time, because it has no specific symptoms and signs, it often appears in the form of complications, which can easily lead to misdiagnosis, causing the child to miss the best treatment time and affect the prognosis.[3] Therefore, timely and accurate diagnosis is crucial. In recent years, with the continuous development of science and technology and the continuous improvement of medical level, the diagnostic technology of duplicated kidney malformation has been developed, which has promoted the widespread clinical attention and attention to the treatment of this disease. The most commonly

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used examination methods at present are CT and MRI. Among them, CT has high density resolution and spatial resolution, which can clearly show the morphology, structure and pathological conditions of the kidneys, and can perform three-dimensional reconstruction, which helps to understand the pathological conditions more comprehensively, but it has poor soft tissue display.[4] MRI has a high resolution for soft tissues, can image in multiple directions, can better display bones and soft tissues, and can evaluate the anatomical structure of the urinary system, but its examination time is longer and it is more sensitive to motion artifacts.[5] At the same time, there are few detailed reports on the diagnostic value of MRI combined with CT in children with duplication of kidney. Therefore, in order to improve the diagnostic rate of duplication of kidney, this study combined the two for the diagnosis of duplication of kidney in children, aiming to provide a reference for clinical practice. The results are reported as follows.

MATERIALS AND METHODS

General Data Analysis

The clinical data of 40 children with duplication of kidney who were admitted to our hospital from January 2019 to January 2024 and confirmed by surgery were collected. Among them, there were 13 males and 27 females. The patients were aged 1 month to 13 years old, with an average age of (5.72 ± 1.26) years. Among them, 38 cases were unilateral (17 left -sided cases and 21 right-sided cases), and 2 cases were bilateral. There were 5 cases of developmental type, 22 cases of hydronephrosis type, and 13 cases of dysplasia type. Inclusion criteria: 1) confirmed by surgery; 2) aged 1 month to 13 years; 3) no contraindications for CT and MRI examination; 4) complete clinical data. Exclusion criteria: 1) patients with combined hypospadias, single kidney loss, and congenital megaureter; 2) patients with poor compliance. 28 patients had symptoms such as dysuria, fever, and hematuria, and the remaining 12 patients were found to have duplication of kidney due to other examinations.

Inspection Method

CT examination. It was performed using a Philips 64-slice volumetric CT scanner. Patients were positioned supine, and scans were performed from the upper pole of the kidney to the pubic symphysis. After a plain scan, the contrast agent iohexol was injected via the antecubital vein. Parenchymal and excretory phase scans were performed 30 to 45 seconds and 5 minutes after contrast injection. Parameters included tube voltage 120 kV, tube current 180 to 260 mA, and slice thickness 5 mm. Data were transferred to a workstation for image post-processing using volume rendering, maximum intensity projection, multiplanar, and curved reconstruction, resulting in multi-dimensional 2D and 3D images of the urinary tract.

MRI Examination. A Philips 1.5 T MRI system was used with the patient in the supine position, using a standard abdominal coil. The costophrenic angles and pubic symphysis were covered. Axial scanning parameters were T1WI and T2WI sequences, with a 1-mm slice spacing, a 1-mm slice thickness, and a 256 × 256 matrix. Coronal and sagittal scans were performed with fat -suppressed signal sequences, and the fat-suppressed sequence was T2WI.

Diagnostic Criteria

Two chief physicians of the imaging department reviewed the films and compared the imaging results of the kidneys, ureters, and bladder with the postoperative results. If the preoperative imaging results were consistent with the postoperative results, it was confirmed; if some diagnostic results were inconsistent with the postoperative results, it was partially consistent; if all diagnostic errors were completely inconsistent; if some or all of them were inconsistent, it was undiagnosed. Classification criteria:[6] 1) Developmental type: the upper renal cardia is well developed and similar to the lower renal cardia; 2) Hydronephrosis type: hydronephrosis of the upper renal cardia, ureteral obstruction, and combined with ureterocele; 3) Hypoplastic type: the upper renal cardia is small, partially vesicular or mulberry-shaped, with a small amount of fluid in the renal cardia and ectopic ureteral opening.

Statistical Analysis

SPSS 24.0 software was used to analyze the data. Enumeration data were expressed as (n). $\chi 2^{test}$ and Fisher's exact probability were used for analysis. $P < .05$ was considered significant.

RESULTS

Analysis of CT and MRI Diagnostic Results of Duplication of Kidney

Diagnosis rate of CT combined with MRI was higher than that of CT or MRI alone ($P < .05$), and there was no significant difference in the diagnosis rate between CT and MRI ($P > .05$) (Table 1).

Comparison of Diagnostic Accuracy of CT and MRI for Duplication of Kidney Types

The diagnostic accuracy of CT combined with MRI for hydronephrosis-type duplication of kidney was higher than that of CT or MRI alone ($P < .05$). There was no significant difference in the diagnostic accuracy of CT or MRI alone or in combination for developmental and dysplastic duplication of kidney ($P > .05$) (Table 2).

MRI and CT Imaging Features of Duplex Kidney in Children

MRI revealed that the duplicated kidney was longer in length than the normal kidney, with dilated renal pelvis and calyces exhibiting hydrops, which showed high signal intensity on T2WI and low signal intensity on T1WI. The upper renal segment was hydrocystically dilated, with the ureteral segment draining the dilated kidney exhibiting high signal intensity on T2WI and low signal intensity on T1WI. The lower renal segment was displaced outward. CT revealed that the ipsilateral kidney was larger than the contralateral kidney, with thinning of the renal cortex and a cystic, low-density shadow within. Enhanced scans revealed enhanced cystic wall, and delayed scans revealed contrast agent retention in the low-hanging portion of the cystic shadow, forming a fluid-fluid surface.

Figure 1 shows a 2-year-8-month-old girl with duplication of kidney. Figure A is the delayed CT scan of the patient, showing two sets of renal pelvis and calyceal systems in the right kidney, hydronephrosis in the right upper hemisphere, and dilated hydroureter. Figure B is the MRU image of the patient, showing two sets of renal pelvis and calyceal systems in the right kidney, dilated hydroureter in the right upper hemisphere, and abnormal ureteral opening. Figure C is the laparoscopic surgery confirming the patient's right duplication of kidney, hydronephrosis in the right upper hemisphere, and low-positioned and dilated opening of the right duplication of ureter.

DISCUSSION

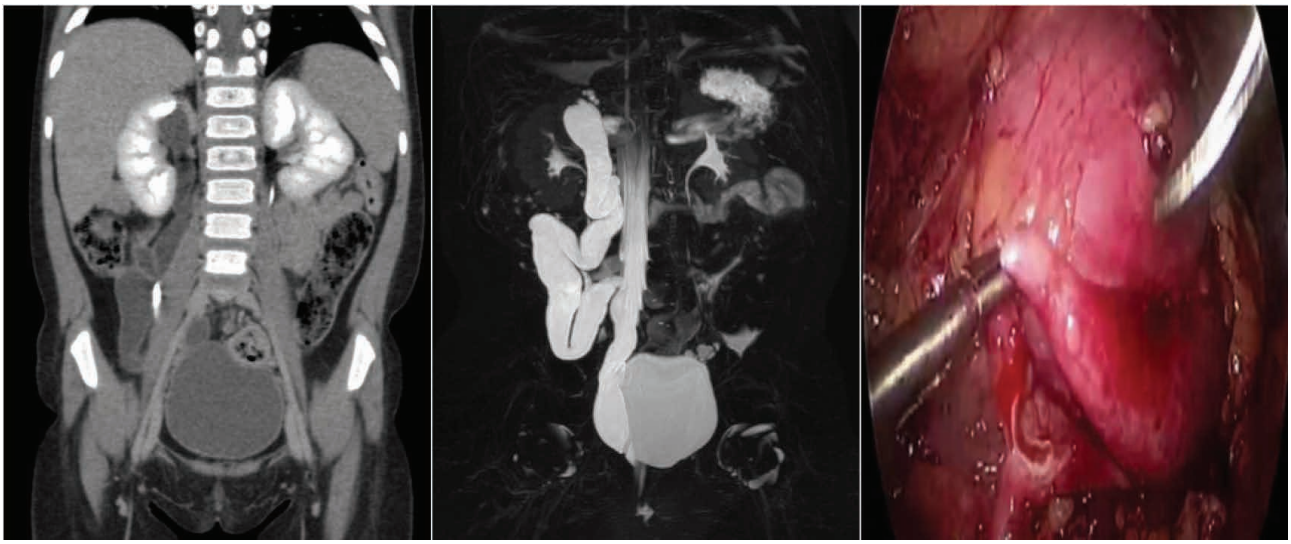
Duplicated kidney is a common collecting system anomaly of the upper urinary tract, with an incidence of 0.5 to 0.8%.[7] It can be divided into developmental, hydronephrosis, and dysplastic types. Most duplicated kidneys have no obvious symptoms and are often discovered during examinations for other diseases.[8] Different pathological classifications also have different treatment methods. Developmental types often have

Table 1. Analysis of CT and MRI Diagnostic Results of Duplication of Kidney ((n) %)

Inspection method	Number of cases	Confirmed diagnosis comparison	
		Confirmed	Undiagnosed
CT	40	32 (80.00)	8 (20.00)
MRI	40	33 (82.50)	7 (17.50)
CT combined with MRI	40	39 (97.50)	1 (2.50)
χ^2		5.000	
P		.025	

Table 2. Comparison of Diagnostic Accuracy of CT and MRI for Duplication of Kidney Types ((n) %)

Imaging examinations	Developmental type (n = 5)	Water accumulation type (n = 22)	Hypoplastic type (n = 13)
CT	4 (80.00)	17 (77.27)	11 (84.62)
MRI	4 (80.00)	18 (81.82)	11 (84.62)
CT combined with MRI	5 (100.0)	22 (100.0)	12 (92.31)
χ^2	-	8.238	0.377
P / Fisher exact probability	1.000	.016	.539



A B C

Figure 1. Images of MRI and CT in Diagnosing Duplication of Kidney in Children

no clinical symptoms and generally do not require surgical treatment; hydronephrosis and dysplasia types are often combined with ureterocele and ectopic opening, which can cause hydroureteral accumulation, compress renal tissue, and cause renal dysplasia. In the long term, it can lead to a gradual decline in renal function and even cause serious complications, requiring surgical treatment.[9-10] Therefore, early diagnosis and surgical treatment are very important.

Ultrasound is easy to operate and can display the upper pole of the kidney in multiple sections. However, it is easy to misdiagnose when there is severe hydronephrosis, and it is not good at displaying the thin lower ureter, which has certain limitations.[11-12] With the continuous improvement of diagnostic technology, CT and MRI are currently used to diagnose duplicated kidney in children. CT has a faster imaging speed and higher spatial resolution, and can avoid interference. It can display the anatomical structure and adjacent tissues of the renal parenchyma, renal calyx, renal pelvis and ureter. Enhanced scanning helps to more intuitively observe the three-dimensional structure of the kidney and its surrounding tissues, display the contents of the duplicated kidney, and can also track and scan the ureter to the bladder to determine whether the ureteral opening is ectopic. After reconstruction, the secretion and excretion function of the kidney can be observed. However, the display of non-dilated duplicated ureters is not clear and intuitive.[13] MRI does not have ionizing radiation and does not require the injection of contrast agents. It has a higher soft tissue resolution and can clearly display the anatomical structure and functional information of the kidney. MRI can provide a more accurate assessment of the subtle structure and morphological changes of the duplicated renal pelvis, renal calyx and ureter.[14] In addition, MRI can also perform multi-directional scanning imaging, and after post-processing, it can display urinary system images in three dimensions, allowing for a more comprehensive observation of the kidneys and surrounding tissues, especially for the display of hydronephrosis and thickened ureters. However, the examination time is longer and it is more sensitive to motion artifacts.[15] The results of this study showed that the diagnostic rate of CT combined with MRI for duplicated kidneys was higher than that of CT or MRI alone, while there was no significant difference in the diagnosis rate between CT and MRI. This indicates that MRI combined with CT can improve the diagnostic efficiency of duplicated kidneys in children. Since MRI and CT are combined, they are complementary in displaying duplicated renal pelvis, renal calyces and ureters, which can provide a more comprehensive understanding of the lesions and improve the accuracy of diagnosis.

However, one patient was missed in the combined diagnosis. The possible reason for this is that the anatomical complexity of the duplicated kidney and the problem of renal hypoplasia in children do increase the difficulty of diagnosis. Therefore, this study believes that it is necessary to comprehensively consider multiple factors when making a diagnosis and use multiple examination methods for comprehensive evaluation to improve the accuracy of diagnosis. The study also found that the diagnostic consistency rate of CT combined with MRI for hydronephrosis-type duplication of kidney was 100%, which was higher than the 77.27 and 81.82% of CT and MRI diagnosis alone, suggesting that CT combined with MRI has a higher diagnostic rate for hydronephrosis-type duplication of kidney and can provide a basis for clinical selection of treatment methods. However, there was no significant difference in the diagnostic consistency rate of CT and MRI alone and in combination for developmental and dysplastic duplication of kidney. The analysis was related to the small sample size included in this study.

MRI combined with CT has a high diagnostic efficacy for duplication of kidney and its classification in children and is worthy of clinical promotion and application. However, this study has certain limitations: the sample size is small, which may cause a certain bias in the results. The sample size will be expanded in the future for further demonstration.

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