Results

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This study was performed over a period from April 2001 to September 2004, on 50 patients with 94 renal unites, 32 males and 18 females. Their ages ranged from 1 to 82 years with average of 57 years. The obtained results were analyzed regarding these points:

- ❖ The image quality.

- ❖ The presence of urinary tract dilatation.

- ❖ The degree of dilation.

- ❖ Whether the dilation is obstructive or non obstructive.

- ❖ The level of obstruction.

- ❖ The cause of obstruction.

Regarding the image quality:

- Techniqualy adequate MR urograms were obtained in all patients (100%). The motions artifacts and superimposing organs represented non significant problem with image interpretation.

- The source images were enough for detection of urinary tract obstruction and the MIP images added no additional information rather than better delineation of the extent of the strictured areas if any.

Regarding the presence of urinary tract dilatation:

1) True diagnosis (standard of reference):

True diagnosis was achieved by evaluation of all available clinical, radiological, surgical and pathological data.

From the examined 94 renal unites 61 unites were dilated, however, only 55 out of the 61 dilated renal unites were obstructed, the resting 6 units were dilated due to pyelonephritis (3 units), previous obstruction with residual dilatation (2 units) and one patient had undergone ureteroplasty for repair of ureteric stricture.

The distribution of the dilated renal unites was as following:

Affected side	Number of patients	Number of renal units
• Right kidney only.	21	21
• Left kidney only	17	17
• Both kidneys	11	22
• Transplanted kidney	1	1
Total	**50**	**61**

Table 5. Number and distribution of the dilated renal systems.

2) MRU:

MRU was performed in all patients and correctly identified 60 renal units with dilated systems.

In one patient, MRU findings were suggestive of bilateral urinary tract dilatation while by other radiological examinations (U.S and CT) and according to the standard of reference, this patient had only left urinary tract dilatation.

In another patient with bilateral urinary tract dilatation, MRU only identified dilated right renal system.

For the presence of dilatation MRU had:

- Sensitivity: 98%

- Specificity: 97%

- Positive predictive value: 98%

- Negative predictive value: 97%

- Accuracy: 98%

3) U.S:

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truly dilated. This misinterpretation was relied to extrarenal pelvis, prominent renal vasculature and distended urinary bladder.

For the presence of dilatation US had:

- Sensitivity: 100%

- Specificity: 76%

- Positive predictive value: 88%

- Negative predictive value: 100%

- Accuracy: 91%

4) IVU:

IVU was performed for 36 patients with renal 72 renal unites. Among the 72 renal unites examined by IVU, 12 unites (17%) were not identified due to poor or non function. The functioning renal unites were identified to be normal, 29 unites (40%) and with dilated urinary tracts, 31 unites (43 %).

IVU showed the following parameters in detection of urinary tract dilation in functioning renal unties:

- Sensitivity: 100%

- Specificity: 100%

- Positive predictive value: 100%

- Negative predictive value: 100%

- Accuracy: 100%

However, with including all the examined renal unites in analysis, IVU had:

- Sensitivity: 72%

- Specificity: 100%

- Positive predictive value: 100%

- Negative predictive value: 71%

- Accuracy: 83%

5) Computed tomography (CT):

CT were performed for 34 patients with 64 renal unites and correctly identified dilated 40 urinary tracts with:

- Sensitivity: 100%

- Specificity: 100%

- Positive predictive value: 100%

- Negative predictive value: 100%

- Accuracy: 100%

Statistical analysis of MRU and other imaging modalities in detection of dilated urinary tract compared with the standard of reference is plotted in *table 6*.

Statistics \ Modality	MRU	US	IVU$_1$	IVU$_2$	CT
• Sensitivity	98%	100%	100%	72%	100%
• Specificity	97%	76%	100%	100%	100%
• PPV	98%	88%	100%	100%	100%
• NPV	97%	100%	100%	71%	100%
• Accuracy	98%	91%	100%	83%	100%

Table 6. Statistical analysis of MRU and other imaging modalities in detection of dilated urinary tract. *IVU$_1$, IVU results in only functioning renal unties; IVU$_2$, IVU results in all examined functioning renal unties; PPV, Positive predictive value; NPV, Negative predictive value.*

Regarding the degree of dilation:

1) Standard of reference:

The dilated renal systems were classified to:

- Mild hydronephrosis: 17 renal unites.
- Moderate hydronephrosis: 24 renal unites.
- Sever hydronephrosis: 20 renal unites.

2) MRU:

MRU correctly depicted the degree of urinary tract dilation in 58 renal unites with an accuracy of 95%. Two renal unites with mild urinary tract dilation as proved by the Standard of reference, were estimated by MRU to be moderately dilated. One renal unites with moderate urinary tract dilation as proved by the Standard of reference, were estimated by MRU to be markedly dilated.

This misinterpretation was relied to diuretic administration before MRU aggravating the degree of dilatation.

3) IVU, CT, US, Antegrade and retrograde pyelography:

IVU in the functioning renal units, CT, US, Antegrade and retrograde pyelography revealed 100% accuracy in grading the urinary tract dilation.

Regarding whether the dilation is obstructive or non obstructive:

1) Standard of reference:

Only 55 out of the 61 dilated renal unites were obstructed, the resting 6 units were dilated due to pyelonephritis (3 unites), previous obstruction with residual dilatation (2 unites) one patient had undergone ureteroplasty for repair of ureteric stricture.

On the other hand, two patients had non dilated urinary tracts study despite the clinical and laboratory data strongly suggestive of obstruction. One of them had an occult ureteropelvic obstruction and in the other one, the obstruction was too early to cause detectable urinary tract dilatation

The distribution of the obstructed and non obstructed, dilated and non dilated renal systems is plotted in *table 7*

Dilatation Obstruction	Dilated	Non dilated	Total
Obstructed renal systems	55	2	57
Non obstructed renal systems	6	31	37
Total	61	33	94

Table 7. Number and distribution of obstructed, non obstructed, dilated and non dilated renal systems.

2) Diuretic renography:

Diuretic renography was performed for 12 patients with 23 renal units, 14 of them were dilated, 6 were normal and 3 renal units were non-perfused. It differentiated correctly between obstructed & non obstructed systems in 11 renal units 9 of them were obstructed & 2 were not obstructed.

3) Antegrade and retrograde pyelography:

Antegrade and retrograde pyelography correctly differentiated between obstructed & non obstructed renal systems in all the examined patients with 100% accuracy.

4) IVU:

Among the 31 dilated renal systems detected by IVU, 21 systems were classified to obstructed and non obstructed with 68% accuracy.

5) MRU

Excretory MRU differentiated correctly between obstructed & non obstructed systems in 8 renal units out of 11 unites with an accuracy of 77% while static MRU didn't differentiate between obstructed & non obstructed systems .

6) CT:

Contrast enhanced CT correctly differentiated between obstructed & non obstructed systems in 9 renal units out of 13 dilated unites with an accuracy of 71% while non enhanced CT failed to differentiate between obstructed & non obstructed renal systems

7) US:

US failed to differentiate between obstructed & non obstructed renal systems.

The sensitivity of differentiation between obstructed & non obstructed systems by MRU and other imaging modalities are shown in *table 8.*

Modality	Differentiated unites / Dilated unites	Accuracy
• Diuretic renography	11/14	82%
• Excretory MRU	8/11	77%
• IVU	21/31	68%
• US	0/61	0%
• CT	9/13	71%
• Antegrade & retrograde pyeloureterography	12/12	100%

Table 8. Accuracy of variable imaging modalities in differentiation between obstructed & non obstructed systems dilated urinary tract.

Regarding the level of obstruction:

1) Standard of reference:

The level of urinary tract obstruction was:

Level	Number of renal units
Intrarenal:	9
Proximal ureter & PUJ	10
Midureter	9
Distal ureter & VUJ	16
bladder	7
Bladder neck	6
Total	57

Table 9. The final diagnosis of level of obstruction.

2) MRU:

MRU correctly detected the level of obstruction in 54 out of 57 obstructed renal units with an accuracy of 96%.

3) IVU:

IVU correctly detected the level of obstruction in 25 out of 31 obstructed, functioning renal units with 81% accuracy.

4) US:

US correctly detected the level of obstruction in 17 out of 57 obstructed renal units with an accuracy of 29%.

5) CT:

CT correctly detected the level of obstruction in 33 out of 40 obstructed renal units with 82% accuracy.

6) Antegrade & retrograde pyeloureterography:

Antegrade & retrograde pyeloureterography were performed in 12 renal units and correctly detected the level of obstruction in the obstructed renal units with an accuracy of 100%.

The accuracy of detection of the obstruction level by MRU and other imaging modalities are shown in *table 10.*

Modality	Detection of level	Accuracy
• MRU	54/57	96%
• IVU$_1$	25/31	81%
• IVU$_2$	25/43	58%
• US	17/57	29%
• CT	33/40	82%
• Antegrade & retrograde pyeloureterography	12/12	100%

Table 10. Accuracy of variable imaging modalities in detection of the level of obstruction. *IVU$_1$, IVU results in only functioning renal unties; IVU$_2$, IVU results in all examined functioning renal unties.*

MRU was the best modality for localization of the level of obstruction while U.S was the weakest one as the most of the ureters couldn't be detected because of the overlying bowel loops.

Regarding the cause of obstruction:

1) Standard of reference:

The final diagnoses of the causes of obstruction are listed in table *(11)*.

Causes	Number of patients	Number of units
● **Stones**	23*	24
▪ Renal	7	7
▪ Upper ureteric	4	4
▪ Midureteric	5	5
▪ Lower ureteric	8	8
● **Stricture***	7*	8
▪ Upper ureteric	2	2
▪ Midureteric	3	3
▪ Lower ureteric	3	3
● **Pelvi-ureteric junction obstruction***	3	3
● **Renal tumor**	1	1
● **Renal trauma**	1	1
● **Transplanted kidney** (strictured ureteric implantation)	1	1
● **Ureteric tumor**	1	1
● **Retrocaval ureter**	1	1
● **Compression with external mass**	1 (uterine mass)	1
● **Fibrosis** (postoperative fibrous band)	1	1
● **Reflux**	1	2
● **Cancer bladder**	5	5
● **Neurogenic bladder**	1	2
● **Benign prostatic enlargement**	1	2
● **Urethral stricture**	1	2
● **Urethral neoplasm**	1	2
Total	50	57

Table 11. The final diagnosis of causes of obstruction.

23*, *1 patient with bilateral stones;* 7*, *1 patient with bilateral stricture;* Stricture*, *congenital and acquired due to chronic stone formation;* Pelvi-ureteric junction obstruction*, *congenital and acquired due to chronic stone formation.*

MRU:

MRU correctly identified the cause of obstruction in 41 patients with 46 obstructed renal unites:

- 16 patients (17 renal unites) with renal and ureteric stones, however, the stone appearance were non specific appearing as signal void resembling blood clot or neoplasm. Sometimes small stones were not seen in the MIP images and seen only in the source images.

- 7 (8 renal unites) patients with strictures.

- 3 patients with pelvi-ureteric junction obstruction.

- 1 patient with renal tumor.

- 1 patient with renal trauma.

- 1 patient with ureteric tumor.

- 1 patient with retrocaval right ureter.

- 1 patient with uterine enlargement and mass compressing the strictured left lower ureter.

- 1 patient with postoperative fibrous band compressing the right lower ureter.

- 5 patients with cancer bladder.

- 1 patient with neurogenic bladder due to spinal dysraphism.

- 1 patient with benign prostatic enlargement.

- 1 patient with urethral neoplasm.

- 1 patient with obstructed transplanted kidney due to calcified implantation stenosis.

MRU failed to identify the cause of obstruction in 9 patients:

- 7 patients with renal and ureteric stones, the non identified stones were small, less than 5 mm.

- 1 patient with bilateral ureteric reflux.

- 1 patient with post-traumatic urethral stricture.

MRU correctly identified 17 out of 24 renal and ureteric stones (71%) and 29 out of 33 other causes of obstruction (90%)

The overall accuracy of MRU in detecting the causes of obstruction was 82%.

2) PUT:

PUT has been performed for all patients, alone and as a part of IVP. PUT correctly detected 19 renal and ureteric stones.

The non diagnosed stones were radiolucent (2stones) and 3 small radio-opaque stones, 5mm left renal stone, 6mm right midureteric stone and 5mm left lower ureteric stone were obscured with the superimposing bowel loops in a poorly prepared patient.

In two patients, calcified phliboliths were thought to be stones.

For diagnosis of renal and ureteric stones, PUT had:

- Sensitivity: 79%
- Specificity: 94%
- Positive predictive value: 90%
- Negative predictive value: 86%
- Accuracy: 88%

3) IVU:

Among the examined 36 patients, IVU correctly identified the cause of obstruction in 23 patients:

- 14 patients (15 renal unites) with renal and ureteric stones. The non detected stones were radiolucent, small radio-opaque stones & midureteric.
- 4 patients (5 renal unites) with ureteric stricture.
- 2 patients with PUJ obstruction.
- 2 patients with cancer bladder.
- 1 patient (2 renal unites) with benign prostatic enlargement.

IVU showed 84% accuracy in detection of the causes of urinary tract obstruction in functioning renal unties while the accuracy was only 60% with

- 1 patient with posttraumatic urethral stricture.

- 1 patient with urethral neoplasm.

CT showed 82 % accuracy in detection of the causes of urinary tract obstruction. CT correctly identified 23 out of 23 renal and ureteric stones (100%) and 10 out of 14 other causes of obstruction (71%).

6) Antegrade and retrograde pyelography:

Antegrade and retrograde pyelography correctly identified the cause of obstruction in all the examined patients with 100% accuracy:

- 6 patients with ureteric stones.

- 1 patient with PUJ obstruction.

- 4 patients with ureteric strictures.

- 1 patient with ureteric tumor.

The accuracy of detection of the cause of obstruction by MRU and other imaging modalities are shown in *table 12.*

Modality	Detection of cause	Accuracy
• **MRU**	46/57	81%
• **IVU$_1$**	26/31	84%
• **IVU$_2$**	26/43	60%
• **CT**	33/37	89%
• **US**	17/57	29%
• **Antegrade & retrograde pyeloureterography**	12/12	100%

Table 12. The accuracy of detection of the cause of obstruction by MRU and other imaging modalities. *IVU$_1$, IVU results in only functioning renal unties; IVU$_2$, IVU results in all examined functioning renal unties.*