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Role of Magnetic Resonance Urography (MRU) as a Single Imaging Modality in Evaluation of Patients with Pelvi-Ureteric Junction Obstruction

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Abstract: *The objective of this study was to evaluate the Role of MRU as a single imaging modality in evaluation of Pelvi-ureteric junction obstruction.*
40 patients of hydronephrosis suspected to have PUJ obstruction were enrolled for the study from May 2010 to Nov. 2012. All patients under went USG, intravenous Urography (IVU), Glomerular filtration rate (GFR) Calculation by Cockcroft-Gault formula and renal DTPA Scan for determining split renal function and GFR calculation of each kidney. MRU was done to determine the anatomical details and function of each renal unit. MRU was performed on a 1.5 tesla unit (Magneton Avento; Siemens, Erlangen, Germany). Static T2-weighted Magnetic Resonance Urography (MRU) was performed by using a standard fast spin echo technique. Dynamic study was performed after injecting intravenous diuretic followed by Gadolinium contrast media.
Morphological results of MRU were compared with USG, IVU, manual GFR and Renal DTPA scan. The anatomical findings were compared with operative findings.Stastical analysis was performed and data expressed as mean ±SD. MRU GFR, DTPA GFR and manual GFR were compared by Wilcoxson Method.
MRU showed morphology in 39 out of 40 patients (97.5%) and a close correlation was observed between DTPA-GFR, and MRU-GFR (P<0.0001).
We concluded that MRU can provide complete diagnostic evaluation of entire urinary tract in a single session and has potential to replace multiple investigations.

Keywords:
Pelvi-ureteric junction obstruction (PUJO)
MRU (Magnetic Resonance Imaging)
IVU (Intravenous Urography)

I. Introduction:

Obstructive uropathy refers to structural or functional changes in urinary tract that impede the normal flow of urine. It is the eventual outcome of most urological disorders. like calculi, tumors, strictures and anatomical abnormalities and can result in pain, urinary tract infection, loss in renal function, or possibly sepsis and death[(1)].Progressive back pressure on the kidneys and ureters can occur and cause hydroureter and hydronephrosis. Hydronephrosis can cause permanent nephron damage and renal failure [(2)].Symptoms and signs vary with the site, degree and rapidity of onset of obstructive uropathy. Most of the patients are asymptomatic. Pain is most common when obstruction acutely distends the bladder, collecting system (i.e. ureters plus renal calyces), or renal capsule. Upper ureteral or renal pelvic lesions cause flank pain, whereas lower ureteral obstruction causes pain that may radiate to testicles or labia. The distribution of renal and ureteral pain is usually along T11 and T12 dermatomes. Hydronephrosis may occasionally produce a palpable flank mass, particularly in massive hydronephrosis of infancy and childhood. Pelviureteric junction obstruction (PUJO) is a condition in which urine is unable to travel from the renal pelvis to the bladder because of a blockage occurring at the UPJ. The etiology of PUJ obstruction includes both congenital and acquired conditions. The majority of cases are congenital. Acquired conditions include stone disease, postoperative or inflammatory strictures, and Urothelial neoplasms. Pelviureteric junction obstruction (PUJO) is the most common cause of antenatal and neonatal hydronephrosis [(3)]. A congenital PUJ obstruction may be due to either an intrinsic or an extrinsic cause, or in some cases, both. Most common intrinsic obstructions are the result of an adynamic segment. [(4)] or an alteration of the collagen fibers and composition between and around the muscular cells [(5)]. The role of aberrant lower pole vessels as an extrinsic cause of UPJ obstruction is less clear in the pathogenesis of the disease[(6)]. The standard

repair for UPJ obstruction has historically been open pyeloplasty. The strategy for management of renal obstruction is based upon precise delineation of the anatomy of both Reno-ureteral units, as well as accurate estimation of the split renal function. Magnetic Resonance Urography (MRU): static fluid imaging wherein static or slow-flowing fluids in the body are imaged as high signal intensity, high contrast, bright structures against a dark background with very low signal intensity, referred to by some researchers as 'hydrographic contrast'[7]. Magnetic resonance imaging (MRI) allows for a comprehensive examination of almost the complete spectrum of urologic diseases, including congenital malformations. The most important advantages of MRI are the free choice of slice orientation, high soft tissue contrast and high resolution as well as the lack of radiation. Contrast enhanced MRI represents the imaging modality of choice in patients with reduced renal function or known allergy against iodinated contrast agent [8]. MRU performed with contrast material can meet all demands of clinical urography and, in some cases, could replace conventional X-ray urography [9,11&12].The first MR image was published in 1973[10], and the first study performed on a human took place on July 3, 1977. By combining unenhanced sequences with multiphase contrast enhanced and excretory phase imaging, a comprehensive assessment of the kidneys, ureters, bladder and surrounding structures is possible with image quality rivaling that obtained with other techniques.Allergies to gadolinium based contrast agents are exceedingly rare occurring at a rate of 0.03-0.1% [13,14].There have been reports of serious adverse reaction called Nephrogenic Systemic Fibrosis (NFS) that can occur after exposure to extracellular, non-ionic low osmolar gadolinium based contrast agents [15, 16]. Gadolinium based contrast (GBC) agents are contraindicated in patients on dialysis regardless of availability of rapid treatment after exposure.

II. Material And Methodes

This study was conducted in the departments of Urology and Radiodiagnosis & Imaging, Sher-i-Kashmir Institute of Medical Sciences, Srinagar. This prospective study included 40 patients (>14yrs of age) of hydronephrosis on USG suspected due to PUJ Obstruction. Patients were evaluated by history, clinical examination and USG abdomen. All patients under went intravenous Urography (IVU), Glomerular filtration rate (GFR) Calculation by Cockcroft-Gault formula and DTPA Scan for determining split renal function and GFR calculation of each kidney. All patients underwent gadolinium-enhanced magnetic resonance imaging (Gd-MRI) to determine the anatomy and function of renal units by calculating the GFR of each unit.

Patients above 14 years of age with hydronephrosis on USG and IVU suspected due to PUJ Obstruction with normal kidney function were included in the study. Patients with Pacemakers, Ferro-magnetic implants, Patients who had claustrophobia, Patients with Vagus nerve stimulators, Implanted Cardioverters-Defibrillators (ICD), Loop recorders, cochlear implants, deep brain stimulators, Insulin pumps were excluded from study. All the information was recorded in a pre-structured proforma and data analyzed by appropriate statistical analysis.

The study was performed on a 1.5 tesla unit (Magneton Avento; Siemens, Erlangen, Germany). Static T2-weighted Magnetic Resonance Urography (MRU) was performed by using a standard fast spin echo technique that included coronal multislice T2 weighted MRU. Dynamic study was performed after injecting intravenous diuretic followed immediately by Gadolinium contrast and contrast enhanced series was started immediately after contrast injection.All patients were subjected to open surgery which was gold standard to confirm the findings of MRU. Stastical analysis was performed and data expressed as mean ± SD. MRU GFR, DTPA GFR and manual GFR were compared.

III. Results

The total number of patients included in the study was 40, out of which 22 (55%) were males and 18 (45%) females with mean age 35.3 years. 18 (45%) out of 40 patients were asymptomatic. flank pain was second most common presentation and was present in 16 (40%) of patients.

On USG hydronephrosis was present in all patients (40, 100%) patients. PUJ Obstruction was detected only in 31(77.5%) patients as a cause for hydronephrosis on Ultrasonography (USG). Secondary Renal calculi (non-obstructing) were found in 11 (27.5%) of patients on KUB X-Ray. Intra-venous pyelography (IVP) was done in all patients. Contrast uptake was normal in 37 patients and decreased in 3. PUJ obstruction was detected in 36 (90%) patients. Renal DTPA scan was done in all patients. 32 (80%) patients showed slow Pelvi-Calyceal drainage with obstruction. Mean uptake of contrast in involved kidneys was 5.3±1.7 and the mean split function of involved kidneys was 44.3±8.6%. Mean global GFR was 108±24.2 ml/min with mean GFR of affected kidneys as 53.6±15.5 ml/min.

All patients were subjected to Magnetic Resonance Urography (MRU) after informed consent from Patient or caretaker. All renal units examined were normal in position. Contrast uptake on MRU was normal in 37 (92.5%) renal units and decreased in 3 (7.5%) units. Out of 40 involved renal units parenchymal thickness was decreased in 5 (12.5%) renal units and contrast execration was decreased in 3 units. Hydronephrosis was found in 40 (100 %) of renal units with 6 (15%) showed mild hydronephrosis 7(17.5%) showing moderate

hydronephrosis and 27 (67.5%) severe hydronephrosis. Pelvi-calycel system was dilated in 22(55%) and grossly dilated in 17(42.5%). Narrow segment PUJ obstruction was found in 39(97.5%) renal units while in one patient PUJO was not found. All patients were subjected to surgery. PUJO was found in all 40(100%) of patients intra-operatively. Anderson-Hynes pyeloplasty was done in all patients. Aberrant vessel was not detected in any patient with Gd-MRU or intra-operatively.

Taking surgery as gold standard for confirming the presence of PUJ Obstruction, the sensitivity of different imaging modalities was 77.5% for USG, 90% for IVP, 80% for DTPA and 97.5% for MRU. 30 (75%) out of 40 patients had PUJO on left side while 10 (25%) had on right.

The mean hospital stay was 5 days (ranging from 4-6 days), all patients were catheterized before surgery and catheter was removed on 3-5 days (mean= 3.1 day), the mean time for drain removal was 4.7 days. One of the patients developed SSI while 3 developed anastomotic leak which was managed non-operatively. All patients were followed in our department with mean follow-up period of 14.2 months (range 6-23 months).

IV. Discussion

After establishing the role of MRI in urological malignancy, e.g. renal and adrenal tumors, its use for diagnosing benign diseases has been increasing rapidly. Different MRI techniques, e.g. MRA, MRU and Gd-MRI, have encouraged researchers to adopt an 'all-in-one' approach to replace different imaging methods, which saves time, effort and cost [(19)]**.** This approach has provided accurate information as a sole imaging method for evaluating live donors of kidneys [(20)].In the present era of minimally invasive treatment, preoperative evaluation of patients with PUJ obstruction has comprised several complementary imaging methods. USG and IVU are useful for morphological diagnosis, while renal isotopic scintigraphy is essential for functional evaluation and for diagnosing obstruction **[(18)]**. Recently, identifying the Peri-renal vascular anatomy has gained importance because of the risks and adverse effects of crossing vessels on endopyelotomy techniques [(21)].

Contrast-enhanced MRU produces high-resolution images resulting from the accumulation of bright contrast material in the collecting system and the ureter, which is sufficient to show the ureter distal to the site of obstruction [(22)]. Static MRU has proved very accurate in diagnosing the level and cause of obstruction, especially if the obstruction is not caused by calculi [(23)] but is unable to provide information about renal function. Therefore, Gd-MRI was developed to provide functional data where contrast-enhanced serial images are used to calculate renal clearance (MR clearance). After diuretic administration, a time-intensity curve is plotted [(19, 17)].These findings suggest high accuracy of estimating renal clearance and diagnosis of obstruction by MRI. This is because Gd-DTPA is an excellent indicator of renal function, as it is freely filtered through the glomeruli and it is neither absorbed nor secreted by renal tubules [(24)].

We carried a study entitled "Role of Magnetic Resonance Imaging (MRI) as a imaging method for evaluating patients with Pelviureteric junction obstruction" in the departments of Urology and Radiodiagnosis of our institute. Our study included 40 patients more than 14 years of age with normal renal function (creatinine <1.5 mg/dl) who visited our OPD and were found to have hydronephrosis on USG and IVU. All patients were subjected to renal DTPA scan and Gd-MRU. Surgery was performed in all patients.

In our study the sensitivity and specificity of USG was 77.5% and 50% and sensitivity of MRU was 97.5% respectively which is in conformity of other studies (Katzberg RW, Buonocore MH, Ivanovic M et al).

Apart from the general contraindications of MRI such as claustrophobia and presence of a metallic prosthesis, MRI machines are not available everywhere because they are expensive. The long post-image processing time, and the need for an experienced radiologist to interpret the images, especially to calculate the MR clearance and plot time-intensity curves. The expense of preoperative comprehensive MRI might be compensated as it can replace several imaging method. The long post-processing time can be reduced by improving the software and the experience in interpretation of the different MRI techniques, which can be gained with exposure to more cases.

Our study was performed on 1.5 T magnetic resonance imaging unit (Magnetom Avento; Siemens, Erlangen Germany). All patients were subjected to static and dynamic MRI evaluation. Static T_2 Weighted MRU was first performed for anatomic and morphological evaluation of kidneys and collecting system. Contrast enhanced T_1 weighted sequences were then performed to evaluate the kidney function.

The GFR calculated by MRU in our study correlated well with DTPA GFR and Manual GFR calculated by Cockroft-Gualt formula. The difference(SD) between mean DTPA GFR, Manual GFR and MRU GFR was not significant. The correlation between mean DTPA, Manual and MRU GFR was strong.

Gadolinium is exclusively excreted through kidneys therefore has prolonged half life in patients with renal failure. The possible causal link between NFS and Gd containing contrast materials used in MRI was first identified by Grobner. It has been reported in patients with chronic severe renal failure with GFR < 30 ml/min/1.73m^2, patients with acute renal insufficiency and in patients with renal dysfunction due to Hepato-renal syndrome and in Peri-operative liver transplantation period (25, 26 & 27). In 2007 the pharmacovigilance

working party of European Medicines Agency (EMEA) announced that Gadolinium is contraindicated in patients with GFR < 30ml/min.

None of patients in our study developed NSF. One of our patients developed acute adverse reaction in the form of nausea, vomiting and hypotension. The procedure was abandoned and patient admitted in Emergency Department and was managed with IV fluids and anti-histaminics and steroids. This patient was excluded from Stastical analysis as MRU could not be done.The combination of T2 weighted and contrast enhanced T_1 weighted MRU in our study diagnosed Pelvi-ureteric Junction Obstruction in 97.5% patients.

V. Conclusion

We concluded that Gd-MRU provides superior anatomical and functional information about renoureteral units. MRU is investigation of choice in patients at risk of radiation exposure and allergy to iodinated contrast material and can provide complete diagnostic evaluation of entire urinary tract in a single session and has potential to replace multiple investigations. Gd-MRU can be considered a reliable alternative to other investigations like IVU and DTPA Scan for estimating differential renal function and diagnosing obstruction. The expense of preoperative comprehensive MRI might be compensated as it can replace several imaging method. We conclude that comprehensive MRI is a valuable and accurate method that can reliably replace different imaging methods for the preoperative evaluation of patients with PUJO.

TABLES:

Table 1: Presentation of patients

Presenting Symptoms			
		n	%
Pain Flank	Right	2	5
	Left	10	25
	Bilateral	4	10
Dysuria		13	32.5
Hematuria		6	15
Increased Frequency		6	15
Asymptomatic		18	45

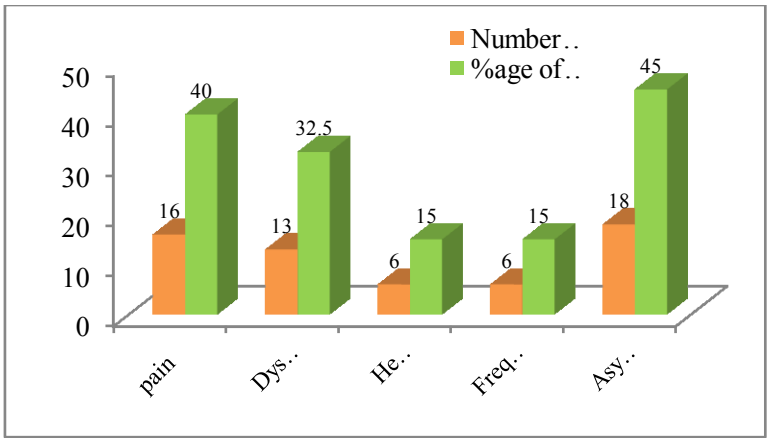

Fig 1: Graphical representation of symptoms of patients

Table 2: Renal Parameters on DTPA Scan

DTPA Scan			
		n	%
Pelvi-Calyceal Drainage	Adequate	8	20.0
	Inadequate	32	80.0
Uptake		5.3 ±1.7(1.3,7.6)	
Split Function		44.3 ±8.6(20,53)	
GFR		53.6 ±15.5(12,72.3)	
GFR(Global)		108.0 ±24.2(50,138.4)	
Normalized GFR		106.7 ±5.4(94,115)	

Table 3: Renal Parameters on MRU

MRU Scan			
		n	%
Position	Normal	40	100.0
Up Take	Normal	37	92.5
	Decreased	3	7.5
Parenchymal Thickness	Normal	35	87.5

	Decreased	5	12.5
Contrast Excretion	Normal	37	92.5
	Decreased	3	7.5
Hydronephrosis	Mild	6	15.0
	Moderate	7	17.5
	Severe	27	67.5
Aberrant Vessel	No	40	100.0

All patients were subjected to Magnetic Resonance Urography (MRU) after informed consent from Patient or caretaker. All renal units examined were normal in position. Contrast uptake on MRU was normal in 37 (92.5%) renal units and decreased in 3 (7.5%) units. Out of 40 involved renal units parenchymal thickness was decreased in 5 (12.5%) renal units and contrast execration was decreased in 3 units. Hydronephrosis was found in 40 (100 %) of renal units with 6 (15%) showed mild hydronephrosis 7(17.5%) showing moderate hydronephrosis and 27 (67.5%) severe hydronephrosis. Pelvi-calycel system was dilated in 22(55%) and grossly dilated in 17(42.5%). Narrow segment PUJ obstruction was found in 39(97.5%) renal units while in one patient PUJO was not found. Aberrant vessel was not detected in any patient with Gd-MRU or intra-operatively.

Table 4: Sensitivity and Specificity of different modalities against MRU

		MRU			
		Present		Absent	
		n	%	n	%
USG	Present	28	82.4	3	50.0
	Absent	6	17.6	3	50.0
IVP	Present	32	94.1	4	66.7
	Absent	2	5.9	2	33.3
TPA	Present	27	79.4	5	83.3
	Absent	7	20.6	1	16.7

For diagnosing primary PUJ Obstruction the sensitivity and specificity of different modalities as against MRU are as, USG 82.4% and 50%, IVP 94.1% and 66.7% while that of DTPA scan are 79.4% and 83.3% respectively

Table 5: sensitivity of different modalities against surgery

		MRU		IVP		DTPA		USG	
	PUJO	Present	Absent	Present	Absent	Present	Absent	Present	Absent
surgery	present	39	1	36	4	32	8	31	9
sensitivity		97.5%		90.0%		80.0%		77.5%	

Taking surgery as gold standard for confirming the presence of PUJ Obstruction, the sensitivity of different imaging modalities was 77.5% for USG, 90% for IVP, 80% for DTPA and 97.5% for MRU.

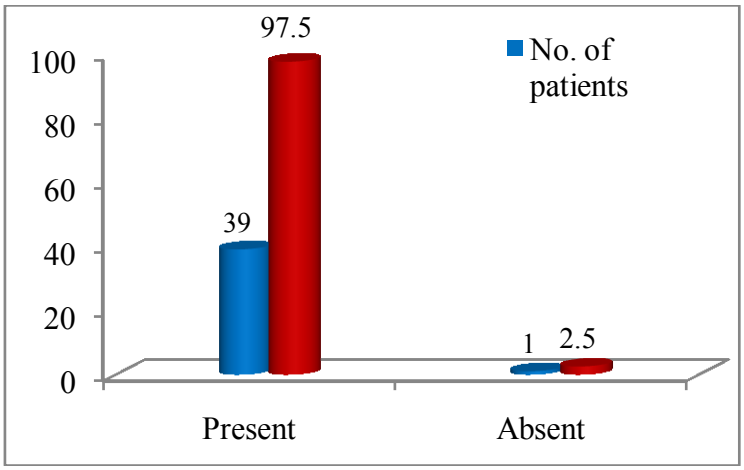

Fig 2: No. and %age of Renal Units with PUJ Obstruction detected on MRU

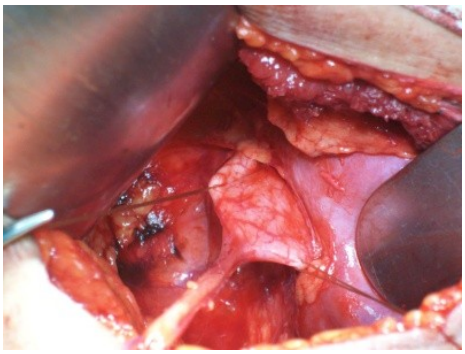

Plate 1: Dilated Renal Pelvis with narrow UPJ

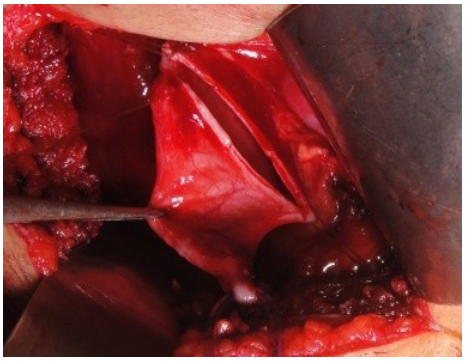

Plate 2: incision made on renal pelvis

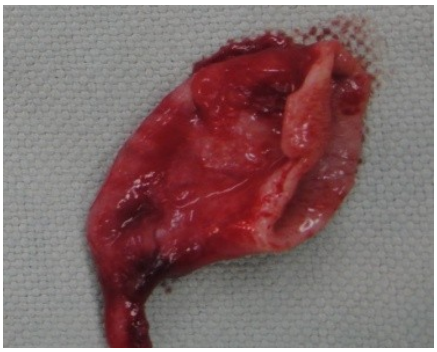

Plate 3: excised Renal Pelvis with narrow segment UPJ

Plate 4: Gd enhanced MRU showing dilated left renal pelvis secondary to PUJ Obstruction

Plate5: T1 (Gd-enhanced) MRU with delayed cortical phase left kidney suggestive of obstruction

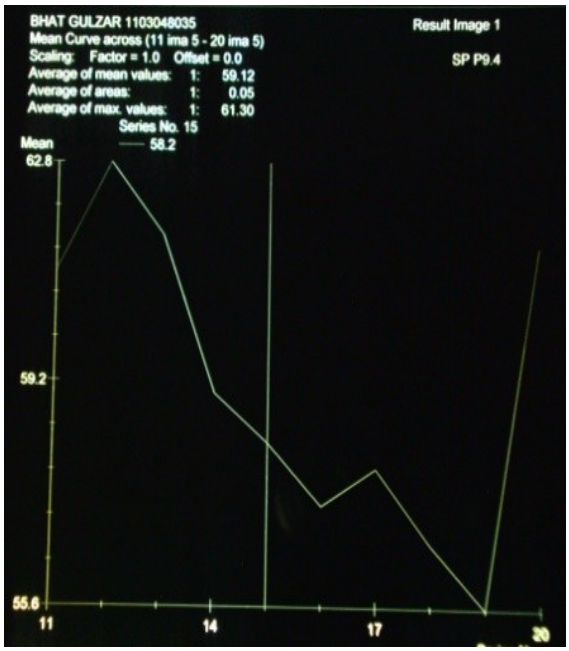

Plate 6: Time intensity curve with mean contrast clearance with obstructive pattern

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