

# Role of Dynamic Magnetic Resonance Imaging in Pelviureteric Junction Obstruction Management

T Chandru<sup>1</sup>, R Neelakandan<sup>2</sup>, K Natarajan<sup>3</sup>

<sup>1</sup>Associate Professor, Department of Urology, Sri Ramachandra Medical Centre, Chennai, Tamil Nadu, India, <sup>2</sup>Assistant Professor, Department of Urology, Sri Ramachandra Medical Centre, Chennai, Tamil Nadu, India, <sup>3</sup>Professor, Department of Urology, Sri Ramachandra Medical Centre, Chennai, Tamil Nadu, India

## Abstract

**Introduction:** Pelviureteric Junction obstruction (PUJO) is one of the most common causes of hydronephrosis and continues to present a challenge to radiologists and urologists, who are unable to accurately predict which patient will benefit from surgery. Dynamic contrast enhanced magnetic resonance (MR) urography has several advantages in the evaluation of PUJO, because, it combines both anatomic and functional information in a single test that does not use ionizing radiation. We have studied whether dynamic contrast enhanced MR imaging (MRI) urography could replace isotope renogram in the functional evaluation of pelviureteric junction obstruction.

**Materials and Methods:** Symptomatic patients diagnosed to have pelviureteric junction obstruction based on ultrasonogram, intravenous urogram, and computed tomogram were included in the study. Isotope renogram and dynamic MR urography were done in all patients. T  $\frac{1}{2}$ , time-activity curves, glomerular filtration rate (GFR), and split renal function calculated from isotope renogram. MR findings were evaluated with regard to the GFR and intrarenal transit time of the contrast. Time-intensity curve is then plotted using inbuilt software. Statistical software was used to analyze the data. The findings of isotope renogram and dynamic MRI (DMRI) were correlated individually with the surgical finding and accuracy was compared. Linear regression analysis was performed to correlate the imaging and surgical procedure done.

**Results:** The calculation of GFR by isotope renogram, showed good correlation with that of DMRI with correlation coefficient 0.93. DMRI was able to pick up the functional status of the renal unit accurately. DMRI had no false positivity, with 20 patients of 21, deemed for pyeloplasty and 11 of 12, deemed for nephrectomy. Correlating with the surgery, the DMRI had a  $X^2_0.000$ , with  $P = 1.000$ , having no statistical significance for the difference compared with surgery. Isotope renogram has a  $P = 0.4279$  with respect to surgery, again showing no statistical significance for the difference in number. Comparing DMRI with isotope renogram, DMRI has a significant  $P = 0.00$  with good negative predictive value. Thus, it outscores isotope renogram in sensitivity.

**Conclusion:** Using DMRI, analysis of renal function is similar to renal scintigraphy. DMRI techniques can be combined to establish a one-stop imaging examination that can replace different imaging methods used for morphological, etiological, and functional evaluation of pelviureteric junction obstruction.

**Key words:** Dynamic magnetic resonance urography, Isotope renogram, Pelviureteric junction obstruction

## INTRODUCTION

Congenital ureteropelvic junction obstruction most often results from intrinsic disease. A frequently found defect is

the presence of an aperistaltic segment of the ureter. In these cases, histopathologic studies reveal that the spiral musculature normally present has been replaced by abnormal longitudinal muscle bundles or fibrous tissue. This results in failure to develop a normal peristaltic wave for the propagation of urine from the renal pelvis to the ureter. Traditional imaging tests have emphasized detection and grading of hydronephrosis with sonography and determination of renal function and obstruction with scintigraphy. The classification of the kidney as obstructed does not predict progressive loss of function and does not identify which patient will benefit from surgery.<sup>[1,2]</sup>

### Access this article online



www.ijss-sn.com

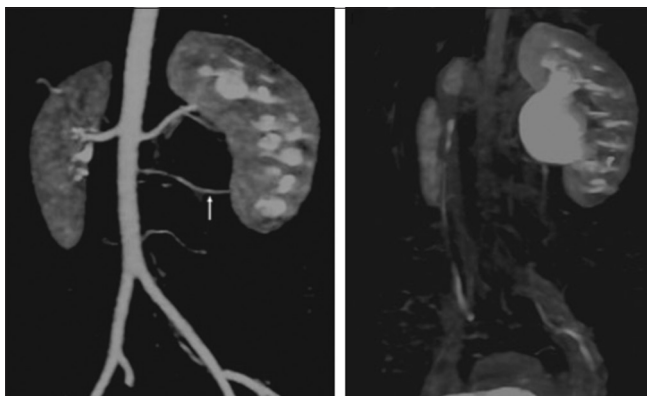
Month of Submission : 11-2017  
Month of Peer Review : 12-2017  
Month of Acceptance : 12-2017  
Month of Publishing : 01-2018

**Corresponding Author:** Dr. T Chandru, Department of Urology, E-2 Urology Out Patients Department, Sri Ramachandra Medical Centre, Chennai, Tamil Nadu, India. Mobile: +91-9500076471. E-mail: surgchandru@yahoo.co.in

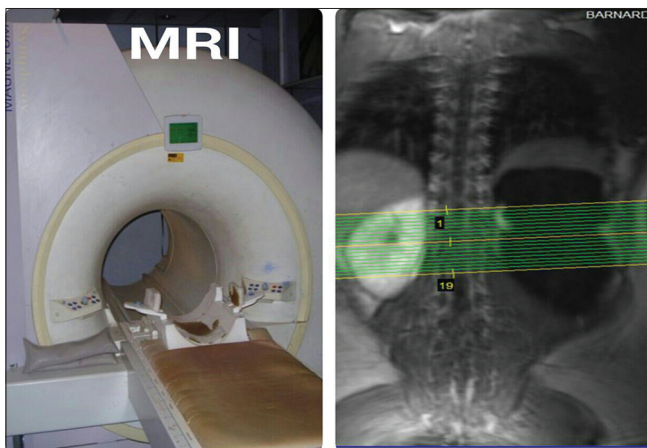
Studies have shown that dynamic contrast enhanced magnetic resonance (MR) urography has several advantages in the evaluation of pelviureteric junction obstruction, because, it combines both anatomic and functional information in a single test that does not use ionizing radiation<sup>[3]</sup> [Figure 1]. MR imaging (MRI) has progressed significantly in recent years because of the development of both hardware and software that are used to generate high-resolution images. Aim of our study was to find out the extent of pelviureteric junction obstruction (PUJO), functional potential of the kidney and to determine if dynamic contrast enhanced MR urography could replace isotope renogram in the functional evaluation of pelviureteric junction obstruction.

## MATERIALS AND METHODS

Symptomatic patients diagnosed to have pelviureteric junction obstruction based on ultrasonogram (USG), intravenous urogram, and computed tomogram were included in the study. 45 patients were included in the study. Informed consent was obtained from all the patients. All



**Figure 1: Magnetic resonance angiography showing a vessel crossing at pelviureteric junction**



**Figure 2: Magnetic resonance imaging**

these patients were investigated with isotope renogram and subsequently, subjected to dynamic MRI (DMRI). Patients with structural defects such as duplex system and horseshoe kidney, patients with B/L PUJO previous surgery, patients with pacemaker and metallic implants, and claustrophobic patients were excluded from the study. Diuretic renogram study was performed and results evaluated according to current recommendations.<sup>[4]</sup> Scintigraphy followed by intravenous (IV) injection of 12  $\mu$ ci/kg technetium-99 m mercaptoacetyltriglycine-3, with a minimum activity of 150  $\mu$ ci. A large field of view gamma camera equipped with low energy all-purpose collimator was used. The window was placed over the photopeak of the tracer and was opened by 20%. A 128  $\times$  128 image matrix was used. Data were collected in 12 s time frames. The scintigraphic examination lasted 40 min, and furosemide was administered along with the tracer (F+0). Region of interests (ROI<sub>s</sub>) was placed by an experienced technician who prepares the imaging material for medical evaluation. Time-activity curves were generated from the background corrected count rates [Figure 2].

All MRI was conducted on a 1.5 T Siemens scanner, with the use of a phased-array torso surface coil. The procedure started by obtaining a coronal localizer (scout image) to identify the abdominal aorta and the origins of the renal arteries, followed by a coronal T2 weighted sequence for the whole of both kidneys and six coronal fast spoiled gradient (FSPGR) images at the center of the kidney. Then, DMRI was performed by IV injection with 0.1 mmol/kg gadodiamide (Gd-DTPA) at 3 ml/s, and the coronal scan series was repeated every 30 s for 5 min. Furosemide (0.3 mg/kg) was injected along with the contrast to assess the contrast medium excretion in response to the diuretic. The total amount of contrast was 20–30 ml according to body weight. Finally, excretory MR urography was performed using contrast enhanced T1 weighted 3 D-FSPGR acquisition at 7–10 min after gadodiamide injection to visualize the collecting system and the ureter. The DMRI curve was generated by drawing a ROI, over the kidney, excluding the renal pelvis, using functional software that merges all series, a curve resembling that from isotope renography was obtained [Figure 3]. The DMRI curve plots the enhancement units versus time, and from the curve, the time to peak, the relative maximum units of enhancement and the response to diuretic were obtained. The mean post-processing time was 60 (45–70) min.

In isotope renogram the activity and the  $T_{1/2}$  of renal signal decay after furosemide administration of each kidney was categorized as being normal, equivocal, or obstructed, with normal kidney having  $T_{1/2}$  of <10 min, equivocal kidneys

had a  $T_{1/2}$  between 10 and 20 min, and obstructed kidneys have a  $T_{1/2}$  more than 20 min. Glomerular filtration rate (GFR) and split renal function calculated.

MR urography findings were evaluated with regard to the GFR and intrarenal transit time of the contrast material. Renal transit time<sup>[5,6]</sup> is used to classify the kidney as being - normal: <245 s, Equivocal: >245–<490 s, and obstructed: >490 s. Time-intensity curve is then plotted using inbuilt software. If there is a gross discrepancy between the isotope renogram and MR findings, then, to assess the salvageability of that renal unit, percutaneous nephrostomy (PCN) to be done and PCN fluid analysis to be done after 1 month. Planned procedure, either pyeloplasty or nephrectomy to be decided based on salvageability results of PCN fluid analyst. Statistical software (SPSS, Version 17) was used to analyze the data. The findings from isotope renogram and DMRI were correlated individually with the surgical finding. The accuracy of isotope renogram and DMRI was individually determined and compared. Linear regression analysis was performed to correlate the imaging and surgical procedure.

## RESULTS

Total number of patients studied 45. The patients ranged in age from 17 to 45 years, with a mean age of 31.21 years. Two patients had pyonephrosis, hence PCN done, one patient had renal calculus and hence excluded from our study. In all the 42 patients, evaluated with isotope renogram, the intrarenal transit of radiotracer was calculated. Total GFR calculated and split renal functions deduced. With isotope renogram, no information was obtained about the renal parenchymal thickness. DMRI post-contrast  $T_1$  weighted coronal images and spoiled gradient were taken. ROI was plotted and time-intensity curves obtained with the help of inbuilt software.

Out of the 42 cases, 9 cases were conservatively managed, as they had good split renal function and unobstructed flow pattern in time-intensity curves. These cases are under follow-up. 33 cases were taken up for surgical intervention. The mean GFR as measured by isotope renogram was 22.5 with a standard deviation of 4.2. The mean GFR as estimated by DMRI was 23.8 with a standard deviation of 3.1. The calculation of GFR by isotope renogram showed good correlation with that of DMRI with correlation coefficient 0.93 [Figure 4]. There was an error in the calculation of GFR using isotope renogram, due to the evaluation of counts using gamma camera. The isotope study and the DMRI were done by the same technician, respectively, for all the cases.

Three patients had a discrepancy of GFR between isotope renogram and DMRI. To decide on the surgical modality to

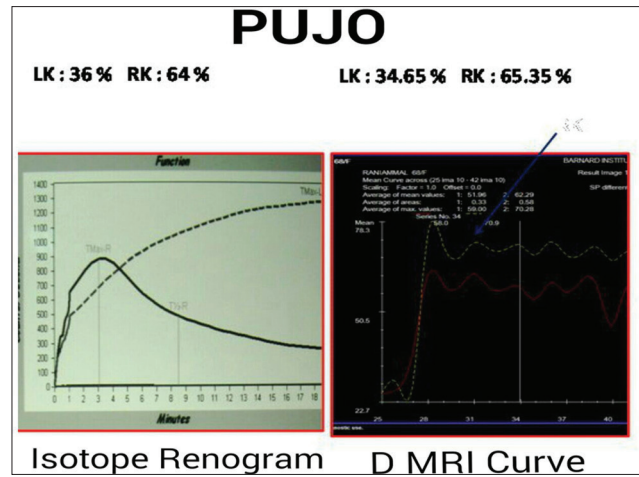


Figure 3: Isotope renogram and dynamic magnetic resonance imaging curves in pelviureteric junction obstruction

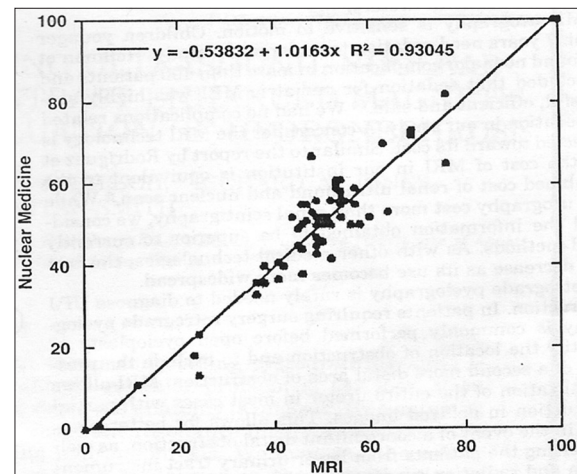


Figure 4: Glomerular filtration rate correlation by isotope renogram and dynamic magnetic resonance imaging

be undertaken, PCN was done on that renal unit. PCN fluid analysis was done after 4 weeks of PCN drainage. All the three patients had a poor quality of PCN fluid, and these patients were deemed to have irreparable renal tubular damage and hence, surgical decision to proceed with laparoscopic nephrectomy was planned. Accuracy of isotope renogram compared to surgery, accurate in 30 patients (90.9%), non-accurate in 3 patients (9.1%). Thus, in these cases, isotope renogram has overestimated the GFR. Two patients could not be evaluated using MRI one due to motion artifact, one due to incidental stone. Out of 33 patients with PUJO, DMRI accurately detected the obstruction in 31 patients (93.93%) and non-conclusive in 2 patients (6.07%). Of 33 patients taken up for surgical intervention, 12 (36.36%) of the patient underwent laparoscopic nephrectomy, while, 21 (63.63%) of the patient underwent pyeloplasty.

Renal transit time detected by either imaging was correlated with each other. 7 Patients had normal transit time and



were conservatively managed with regular follow-up. 2 Patients had renal transit time fallen in the equivocal group. These patients were selected for follow-up. Remaining 33 patients were deemed obstructed and taken up for surgical intervention.

The ureter distal to the obstruction was well visualized in 22 out of 33 patients in MRI, sensitivity 66%. This obviates the role of bulb ureterogram to look for patency or to rule out the double obstruction. This allows for better planning in the event of a concomitant distal obstruction as well as sparing the patient from lower urinary tract instrumentation and radiation exposure. While anatomic imaging of the ureter was not possible with isotope renogram.

DMRI was able to pick up the functional status of the renal unit accurately. DMRI had no false positivity, with 20 patients of 21, deemed for pyeloplasty and 11 of 12, deemed for nephrectomy. Correlating with the surgery, the DMRI had a  $X^2$  0.000, with  $P = 1.000$ , having no statistical significance for the difference compared with surgery. Isotope renogram has a  $P = 0.4279$  with respect to surgery, again showing no statistical significance for the difference in number. Comparing DMRI with isotope renogram, DMRI has a significant  $P = 0.00$  with good negative predictive value. Thus, it outcores isotope renogram in sensitivity [Table 1]. DMRI sensitivity: 100%, specificity: 66%, positive predictive value: 96.7%, and negative predictive value: 100%.

## DISCUSSION

Standardized protocols for obtaining dynamic radionuclide studies have been proposed.<sup>[4,5]</sup> However, in practice, local protocols are often followed which causes problems in the comparison of results between different centers. Even the details of how these (GFR,  $T \frac{1}{2}$ , time to peak activity) parameters are calculated can affect the classification of the drainage pattern.<sup>[6]</sup> Despite its widespread use, diuretic renal scintigraphy is not a reference standard for the diagnosis of obstruction, since the presence or absence of obstruction cannot be distinguished with this modality in at least 15% of the dilated system.<sup>[7,8]</sup> Renal scintigraphy estimates overall and differential renal function. Difficulties in the

evaluation of patients with poor renal function (serum creatinine  $>4$  mg/dl) and patients with capacious collecting systems are the main limitations of these techniques, along with exposure to ionizing radiation.<sup>[9,10,12]</sup> In addition, operator variability in the determination of ROI can affect the accuracy of the differential renal function.<sup>[7,12]</sup> In this study, the calculation of relative renal function by MR urography revealed an excellent correlation with renal scintigraphy ( $r^2 = 0.93$ ). Differences between the MR urography and nuclear estimation of split renal function occurred in cases with significant parenchyma loss or massive dilatation of collecting system. In these instances, MR urography was thought to be more accurate because its greater contrast and spatial resolution allowed us to separate the kidney from background and dilated collecting systems. MR urography was able to detect focal cortical scarring in addition to diffuse parenchyma loss. The advantages of MRI are high soft tissue characterization, capability of direct multiplanar and three-dimensional reformatting, use of non-ionizing radiation, and non-nephrotoxic contrast medium. The disadvantages are motion artifact, cost, and long post image processing time. Similar to the report by Rodríguez *et al.*,<sup>[11]</sup> the cost of MRI is equivalent to the combined cost of renal USG and nuclear scan.

## CONCLUSION

Using DMRI, analysis of renal function is similar to renal scintigraphy, because of superior spatial and contrast resolution. MR urography may be more sensitive than renal scintigraphy in analyzing poorly functioning system. While MR urography, costs more than renal scintigraphy, the information obtained is superior to currently used methods. As with other medical technologies, the cost will decrease as its use becomes more widespread.

DMRI techniques can be combined to establish a one-stop imaging examination that can replace different imaging methods used for morphological, etiological, and functional evaluation of PUJO.

## REFERENCES

1. Neste MG, du Cret RP, Finlay DE, Sane S, Gonzalez R, Boudreau RJ, *et al.* Postoperative diuresis renography and ultrasound in patients undergoing pyeloplasty. Predictors of surgical outcome. Clin Nucl Med 1993;18:872-6.
2. MacNeily AE, Maizels M, Kaplan WE, Firlit CF, Conway JJ. Does early pyeloplasty really avert loss of renal function? A retrospective review. J Urol 1993;150:769-73.
3. Gonzales R, Schimke CM. Pelvic-ureteric junction obstruction in infants and children. Paediatr Clin North Am 2001;48:1505-17.
4. Conway JJ, Maizels M. The "well-tempered" diuretic renogram: A standard method to examine the asymptomatic neonate with hydronephrosis or hydroureteronephrosis. A report from combined meetings of the society for fetal urology and members of the pediatric nuclear medicine council-the

**Table 1: Accuracy of imaging isotope renogram and dynamic MRI**

Imaging	Proposed procedure		$X^2$	P value
	Pyeloplasty	Nephrectomy		
Isotope renogram	24	9	0.629	0.4279
DMRI	20	11	0.000	1.000
Surgery done	21	12		

MRI: Magnetic resonance imaging, DMRI: Dynamic magnetic resonance imaging

- society of nuclear medicine. J Nucl Med 1992;33:2047-51.
5. O'Reilly P, Aurell M, Britton K, Kletter K, Rosenthal L, Testa T, *et al.* Consensus on diuresis renography for investigating the dilated upper urinary tract. Radionuclides in nephrourology group. Consensus committee on diuresis renography. J Nucl Med 1996;37:1872-6.
6. Connolly LP, Zurakowski D, Peters CA, Dicanzio J, Ephraim P, Paltiel HJ, *et al.* Variability of diuresis renography interpretation due to method of post diuretic renal pelvic clearance half time determination J Urol 2000;164:476-1.
7. Dacher J, Pfister C, Thoumas D, Véra P, Liard-Zmuda A, Chomant J, *et al.* Shortcomings of diuresis scintigraphy in evaluating urinary obstruction: Comparison with pressure flow studies. Pediatr Radiol 1999;29:742-7.
8. Peters CA. Urinary tract obstruction in children. J Urol 1995;154:1874-83.
9. Ryan PC, Maher K, Hurley GD, Fitzpatrick JM. The Whitaker test: Experimental analysis in a canine model of partial ureteric obstruction. J Urol 1989;141:387-90.
10. Wen JG, Chen Y, Ringgaard S, Frøkiaer J, Jørgensen TM, Stødkilde-Jørgensen H, *et al.* Evaluation of renal function in normal and hydronephrotic kidneys in rats using gadolinium diethylenetetramine-pentaacetic acid enhanced dynamic magnetic resonance imaging. J Urol 2000;163:1264-70.
11. Rodríguez LV, Spielman D, Herfkens RJ, Shortliffe LD. Magnetic resonance imaging for the evaluation of hydronephrosis, reflux and renal scarring in children. J Urol 2001;166:1023-7.
12. Perez-Brayfield MR, Kirsch AJ, Jones RA, Grattan-Smith JD. A prospective study comparing ultrasound, nuclear scintigraphy and dynamic contrast enhanced magnetic resonance imaging in the evaluation of hydronephrosis. J Urol 2003;170:1330-4.

**How to cite this article:** Chandru T, Neelakandan R, Natarajan K. Role of Dynamic Magnetic Resonance Imaging in Pelviureteric Junction Obstruction Management. Int J Sci Stud 2018;5(10):1-5.

**Source of Support:** Nil, **Conflict of Interest:** None declared.