Original Article

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Paediatrics Section

Role of Diuretic Renography and Ultrasonography in Pelvic Ureteric Junction Obstruction among Infants: A Prospective Interventional Study

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ABSTRACT

Introduction: Renography is a non invasive technique routinely used by clinicians to provide information about kidney structure and function. However, its role in the diagnosis of renovascular disease (especially in patients with renal insufficiency), the exclusion of obstruction, and during the follow-up of patients undergoing pyeloplasty is still controversial.

Aim: To study the changes in Anteroposterior Pelvic Diameter (APD), cortical thickness, split renal function and T½ post pyeloplasty at three months and to determine the usefulness of these parameters in assessing successful pyeloplasty for Pelvic Ureteric Junction Obstruction (PUJO).

Materials and Methods: This prospective non randomised interventional study was conducted in the Department of Nuclear Medicine, PGIMER, Chandigarh, India and Department of Paediatrics, JIPMER, Karaikal, Puducherry, India, from July 2020 to July 2021. A total of 31 infants with persistent postnatal Hydronephrosis (HDN) on Ultrasonography (USG) with no vesicoureteral reflux were included in the study and underwent 99mTc EC renography. The diagnosis of obstruction was determined by visual interpretation, renogram curves, Time to peak (Tmax), and Time from Tmax to T½max parameters. Patients with obstructed patterns in 99mTc EC renography underwent Anderson Hyne's dismembered pyeloplasty. After three months of surgery, 99mTc EC renography and USG were performed on all enrolled patients. The Chi-square test was used for the comparison of the difference in proportion, and the Student's t-test was used for the comparison of the mean difference, between two groups.

Results: The mean age of enrolled infants was 5.79±3.36 months with a male preponderance (27 males and 4 females). Out of 31 infants, 23 (74%) showed an obstructive pattern of drainage on diuretic renogram and underwent Anderson-Hynes dismembered pyeloplasty. The observed difference in the preoperative renal USG anteroposterior diameter (27.85±14.3 mm) and parenchymal thickness (9.6±3.3 mm) vs postoperative anteroposterior diameter (8±3.19 mm) and parenchymal thickness (15.5±4.19 mm) was statistically significant (p-value=0.001). The follow-up renogram scan conducted at three months showed a significant reduction in clearance half-time (T½). However, there was no statistically significant variation in split renal function at three months after pyeloplasty.

Conclusion: Both 99mTc EC renography and USG indicate the likelihood of successful pyeloplasty, and in settings with limited resources, USG may be a viable substitute for early follow-up after pyeloplasty.

Keywords: Hydronephrosis, Pyeloplasty, Renal function, Renogram

INTRODUCTION

The term HDN refers to an aseptic dilation of the renal pelvis and calyces due to obstructive or non obstructive causes. In India, PUJO accounts for 20-60% of Congenital Anomalies of Kidney and Urinary Tract (CAKUT) [1].

Common symptoms of PUJO in infants include haematuria, recurrent urinary tract infections, poor growth, or failure to thrive. USG is used as a screening method because of its high sensitivity [2]. However, surgical intervention cannot be planned solely based on USG findings. Therefore, to differentiate between obstructive and non obstructive HDN, renal scintigraphy is essential [3-5]. Early detection and intervention are important to preserve renal function [6]. Following pyeloplasty, several methods have been proposed, including Intravenous Pyelography (IVP), diuretic renography, magnetic resonance urography and USG at different time intervals [7,8]. It is important to monitor changes in the size of the renal pelvis and the growth of renal parenchyma in the postoperative period. Following up patients after pyeloplasty helps detect recurrent obstruction and prevent further loss of renal function [9].

The most frequently used methods are USG and diuretic renography. Multiple studies have evaluated the role of USG and renogram to determine the success of pyeloplasty [9-12]. However, similar comparative studies are limited in the Indian paediatric population [13]. Therefore, the present prospective study evaluated the role of USG and 99mTc EC renography in the early follow-up of infants with PUJO.

MATERIALS AND METHODS

A prospective non randomised interventional study was conducted in the Department of Nuclear Medicine, PGIMER, Chandigarh, India and Department of Paediatrics, JIPMER, Karaikal, Puducherry, India, from July 2020 to July 2021. The study commenced after approval from Institutional Ethics Committee (IEC approval no: INT/IEC/2020/SPL-1368).

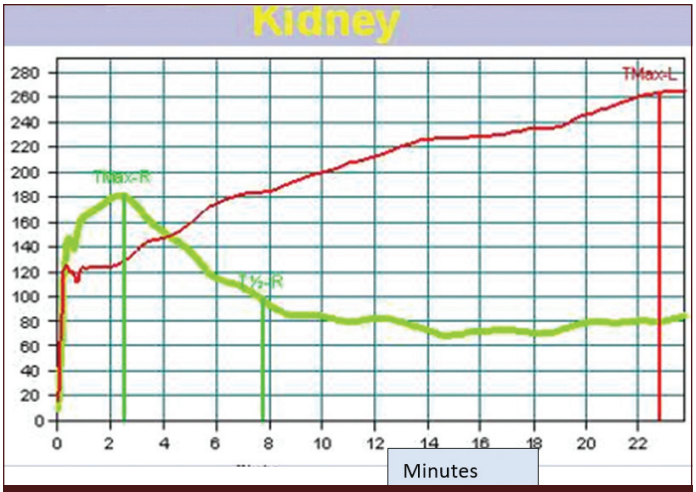
Inclusion criteria: A total of 31 infants with persistent postnatal HDN on USG were included after obtaining written informed consent from parents through convenient sampling.

Exclusion criteria: Infants with co-existing vesicoureteral reflux and other congenital anomalies of the kidney and urinary tract were excluded from the study.

Study Procedure

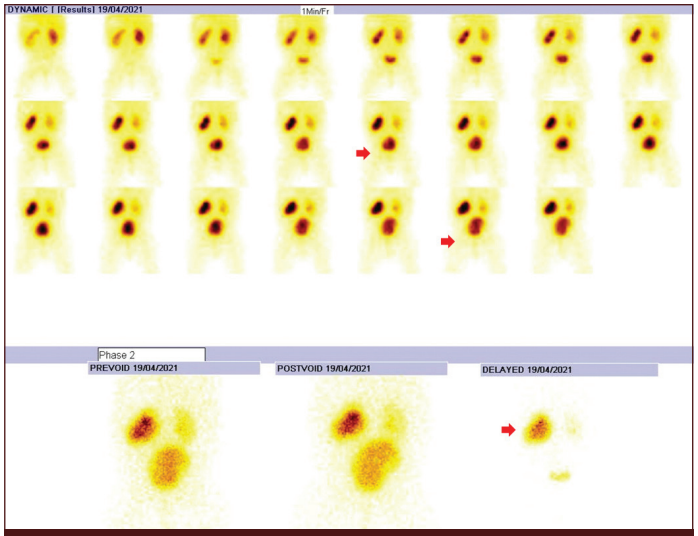
Demographic data such as age and gender were collected from all study participants. Postnatal USG was performed using a convex (3-5 MHz), as well as, a linear footprint transducer (3-12 MHz) [Table/Fig-1]. The renal lengths were recorded in the longest axis, and the degree of calyceal separation was recorded in the lower pole. The size of the dilated pelvis in the anteroposterior dimension and parenchymal thickness were recorded for enrolled infants. A diagnosis of PUJO was determined by renogram curves and T½ (T½ more than 20 minutes). Drainage is considered obstructed when there is inadequate clearance of radiotracer from PCS beyond three hours and T½ is greater than 20 minutes [Table/Fig-2] [14]. Renal scintigraphy (99mTc EC renography) was performed according to the international standardised protocol in the enrolled infants [14]. Images were obtained using a single-head gamma camera (Symbia-E, Siemens, Germany) fitted with a low-energy high-resolution collimator. A diuretic (furosemide) at a dose of 1 mg/kg was injected intravenously, mixed with the radiopharmaceutical, dosage 1-1.5 mCi as per Webster's rule at the start of the scan (F-0 protocol). A dynamic study was recorded in frame mode, and the computer processing program (Syngo, Siemens Healthineers Erlangen, Germany) was used to generate renogram curves for the dynamic study and to assess the Differential Renal Function (DRF) [Table/Fig-3].

[Table/Fig-1]: Left kidney is enlarged (6.7×4.1 cm). Arrow represents Hydronephrosis (HDN) with disproportionate dilatation of pelvis arrow (APD of 30 mm), thinning of cortex and abrupt narrowing at PUJ suggestive of PUJO. Right kidney appears shows normal anatomy, echotexture and pelvic calyceal system. No calculus or HDN seen. Cortical thickness is normal.



[Table/Fig-2]: Renogram curve with counts/second in Y-axis and minutes in X-axis. Left kidney shows uprising curve (Tmax ~23 min) and relative function 39% (red line). Right kidney shows normal time activity curve (green line) with sharp upslope (Tmax ~2 min), clearance T½ of eight minutes and relative function 56%.

The patients with an obstructed pattern on renogram underwent Anderson Hyne's dismembered pyeloplasty. The patients were followed-up with USG and 99mTc EC renography after three months. Any improvement in function and/or drainage was noted and compared with the preoperative findings. Two trained nuclear medicine consultants who were not part of the study were involved in reporting the renogram.



[Table/Fig-3]: Left kidney: Progressive pooling of the tracer activity is noted in the PCS with no evidence of clearance during the dynamic study. Significant tracer activity is noted in the PCS in the prevoid and postvoid static images which persists till three hours (red arrows), suggestive of obstructed drainage (PUJO). Right kidney: Transient pooling of tracer activity is noted in the PCS with significant tracer clearance during the dynamic study. Mild tracer activity is noted in the PCS in the prevoid and postvoid static images which clears adequately by three hours (unobstructed drainage).

STATISTICAL ANALYSIS

Statistical analysis was done using Statistical Package for Social Sciences (SPSS) software version 19.0 (SPSS Inc., Chicago, IL). The continuous variables were expressed as mean with standard deviation, while categorical data were expressed as frequencies and percentages. The Chi-square test was used for the comparison of the difference in proportion between two groups, and the Student t-test was used for the comparison of the mean difference between two groups. A p-value of <0.05 was considered statistically significant.

RESULTS

The mean age of the enrolled infants was 5.79±3.36 months (range 1-12 months) with male preponderance (27 males: 4 females). The mean serum creatinine values (mg/dL) between the obstructed (0.41±0.16) and non obstructed (0.36±0.22) infants were within normal ranges [Table/Fig-4].

Variables	Obstructed (n/Mean±SD)	Non obstructed (n/Mean±SD)
Number of infants	23	8
Sex (male)	21	6
USG APD (Preoperative) mm	27.85±14.3	10±3.29
Urea (mg/dL)	10±3.29	27.85±14.3
Creatinine (mg/dL)	0.41±0.16	0.36±0.22

[Table/Fig-4]: Baseline characteristics.

A statistically significant difference was observed between the obstructed and non obstructed groups on diuretic renogram, for impaired cortical function, clearance T½ (>20 min), and Tmax (min) with 23 (74%) patients displaying an obstructive pattern of drainage [Table/Fig-5].

The observed difference in the preoperative renal USG anteroposterior diameter (27.85±14.3 mm) and parenchymal

EC scan variables	Non obstructed (n=8) (n/Mean±SD)	Obstructed (n=23) (n/Mean±SD)	p-value
Enlarged renal size	0	12 (41.4)	-
Impaired cortical function	01	17 (6.9)	**0.001**
Clearance T½ (>20 min)	4 (13.8)	23 (72.4)	**0.003**
Significant residual renal tracer activity (at 3 hours)	0	17 (81)	-
Tmax (min)	5.12±6.83	19.61±5.23	**0.001**

[Table/Fig-5]: Comparison of 99m Tc EC scan parameters between PUJO and non obstructed HDN.
Student's t-test was used for comparison of mean difference between two groups; The p-value in bold font indicates statistically significant values

thickness (9.6±3.3 mm) vs postoperative anteroposterior diameter (8±3.19 mm) and parenchymal thickness (15.5±4.19 mm) was statistically significant (p-value=0.001). The observed difference in the renography preoperative parameters such as clearance T½ more than 20 minutes and time to peak cortical activity (Tmax) 19.31±5.42 minutes vs postoperative clearance T½ more than 20 minutes and time to peak cortical activity (Tmax) 12.72±5.94 (min) was statistically significant (p-value=0.001) [Table/Fig-6].

Variables	Preoperative (n/Mean±SD)	Postoperative (n/Mean±SD)	p-value
Ultrasound (USG)			
Anteroposterior diameter (mm)	27.85±14.3	8±3.19	**0.001**
Parenchymal thickness (mm)	9.6±3.3	15.5±4.19	**0.001**
Renogram			
Enlarged kidney	12	4	**0.001**
Impaired cortical function (SRF)	35.5±3.9	39.6±4.4	0.27
Clearance T½ more than 20 min (n)	23	09	**0.001**
Time to peak cortical activity (Tmax) (min)	19.31±5.42	12.72±5.94	**0.01**

[Table/Fig-6]: Comparison of preoperative and postoperative USG and renogram parameters.
SRF: Split renal function; Chi-square test was used for comparison of difference in proportion between two groups

[Table/Fig-1] shows USG parameters, with a dilated anteroposterior diameter of the pelvis and severe HDN graded as described by the Society of Foetal Urology [15]. Anderson-Hyne's dismembered pyeloplasty was performed for infants with PUJO, and histopathological signs of fibrosis and dysplasia of the muscularis layer were noted under the light microscope. Eight patients with a non obstructive pattern received antibiotic prophylaxis and were followed up until the study period. Symptomatic improvement, in the form of adequate weight gain without breakthrough urinary tract infections, was observed.

DISCUSSION

Following pyeloplasty, imaging is intended to identify obstruction, as soon as, possible so that subsequent nephron loss can be stopped by interventions. A combination of clinical and radiographic criteria has been used to define success following pyeloplasty for the repair of PUJO in children. Investigations such as USG and RS are most commonly used in postpyeloplasty follow-up. In the present study, the role of both USG and renogram was evaluated three months after pyeloplasty. A considerable reduction in the anteroposterior diameter of the renal pelvis was observed following pyeloplasty, which is consistent with past research showing improvement in APD as a predictor of successful pyeloplasty [16,17]. The parenchymal thickness improved by three months, similar to a study by Kim SO et al., who showed parenchymal thickness as a surrogate marker for improvement in renal function [18]. DRF of the affected kidney postpyeloplasty did not show any improvement; however, T½ had significantly improved. A prior report also found no improvement in DRF following pyeloplasty despite improvement in drainage and HDN, similar to the present study [19]. Research by Chandrasekharam VV et al., found that in patients with impaired preoperative function, the improvement in Split Renal Function (SRF) persisted until one year after surgery [20]. The study involved 68 children with symptomatic pelviureteric junction obstruction, and RSs were taken three months, one year, two years, and five years after surgery. After that time, there was no more improvement, and the SRF stayed steady. Several studies showed that USG alone could be used for the initial assessment after pyeloplasty, with diuretic scintigraphy reserved for the subgroup showing no improvement [9-11].

Cost NG et al., reported that in the majority of children, USG screening three months after pyeloplasty that showed an improvement in HDN would preclude nuclear scan studies [21].

In the current study, renography shows a statistically significant difference between the obstructed and non obstructed groups, confirming its superiority in identifying obstruction [22]. Nonetheless, it necessitates intravenous access, radiation exposure, increased expenditures, and a lengthy study period.

Limitation(s)

Despite the positive results, the low sample size, due to the low number of patients reporting to the hospital during the Coronavirus Disease 2019 (COVID-19) pandemic, was a major drawback.

CONCLUSION(S)

A 99mTc EC renography and USG indicate the likelihood of a successful pyeloplasty. This prospective data reinforces that early 3-month USG alone can be used for the initial assessment after pyeloplasty to detect patients who need further investigation and possibly intervention. Hence, it may be a viable alternative to diuretic renography for the follow-up of PUJO infants in low-resource settings. Additionally, larger prospective studies are required to use USG as an early predictor of pyeloplasty success in resource-limited settings.

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