# **Original Research Article**

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# Renal function estimation done by contrast enhanced computed tomography volume percentage: a better cost-effective alternate for renogram values

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# **ABSTRACT**

**Background:** For optimal management of obstructive uropathy the function of each renoureteral unit needs to be assessed precisely. Usage of nuclear scan for estimation of split renal function has been standard technique till now. Renal parenchymal volume percentage, which is calculated through multislice CT, used as a surrogate marker of split renal function. The aim of the study was to correlate the renal volume percentage calculated from contrast enhanced computed tomography (CECT) of kidney, ureter and bladder (KUB) with split renal function estimated by the gold standard <sup>99m</sup>Tc-DTPA (diethylene triamine pentaacetic acid) among obstructive uropathy patients.

**Methods:** Patients who have been diagnosed as chronic unilateral renal obstruction and were requiring <sup>99m</sup>TC-DTPA nuclear scan for functional assessment of kidneys were included as our study subjects. A total of 46 patients were taken as our study sample and for all these patients CECT KUB was done and the reports were collected and the renal volume percentage was obtained through those images. Correlation was made between the measurements made by nuclear scan and CECT images in unilateral renal obstruction patients.

**Results:** A positive linear correlation was obtained between DTPA nuclear scan and CECT images in the detection of renal volume/renal function with r value 0.904 (p<0.05) in obstructive renal units and similarly among non-obstructive renal units the r value was 0.889 (p<0.001).

**Conclusions:** Though <sup>99m</sup>Tc-DTPA renal scan is a safest choice by considering its less radiation exposure and no contrast requirement still cost and its universal availability make us to consider CECT as a better alternative.

**Keywords:** Obstructive uropathy, DTPA nuclear scan, CECT, Renal volume, Renal function

### **INTRODUCTION**

The most common urological problem reported in the routine practice is obstructive uropathy primarily due to urolithiasis. Studies had shown the incidence of obstructive uropathy varied from 5% to 20% and it is

more so in the western countries. In India, no such studies had been conducted to assess the incidence of obstructive uropathy. Based on the duration of onset obstructive uropathy is classified as acute or chronic and based on the side of involvement it can unilateral or bilateral and based on the renal parenchymal involvement it can be

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complete or incomplete.<sup>3,4</sup> Obstructive uropathy if not diagnosed early and managed it can lead onto irreversible kidney damage. The etiology for obstruction could be benign or malignant and it is mainly determined by the age of the patient. In children uretero-pelvic junction obstruction, congenital urethral valves and meatal stenosis are the most common cause for obstruction.<sup>5</sup> In young adults, presence of a calculi either at KUB is the primary cause while in older patients benign prostatic hyperplasia (BPH), calculi or malignancy are the common causes.<sup>6,7</sup>

The clinical spectrum among patients with obstructive uropathy could be loin pain, lower urinary tract symptoms, fever, mass effect, urine retention, anuria, impaired renal function with uremic signs. Regardless of the patient's age, appropriate diagnosis and prompt surgical or interventional drainage is necessary to avoid irreversible renal damage. Though it is often-reversible, the degree of renal recovery primarily depends on the extent and duration of the obstruction along with the presence or absence of other co morbidities.

For optimal management of obstructive uropathy the function of each renoureteral unit needs to be assessed precisely. The management option ranges from relief of obstruction to partial nephrectomy, which primarily depends on the function of the involved kidney and status of the contralateral renal unit. Traditionally techniques like creatinine clearance, intravenous urogram were used for functional assessment of renal units.<sup>11</sup> Usage of nuclear scan for estimation of split renal function has been standard technique till now. The major limitation of using nuclear scan in assessing the renal function is its lack of widespread availability and its cost. In order to overcome these limitations multislice CT preloaded with software for measuring renal residual parenchymal volume has been recently introduced for renal functional assessment in obstructive uropathy patients.<sup>12</sup> The renal parenchymal volume percentage which is calculated through multislice CT can be used as a surrogate marker of split renal function.4 Few studies have also showed that CT has promising role in assessment of the functional parameters such as perfusion.<sup>13</sup> As of today only very few studies have assessed the efficacy of CT in diagnosing the renal functions in patients with obstructive uropathy and so the present study was conducted with an objective to correlate the renal volume percentage calculated from CECT KUB with split renal function estimated by the gold standard 99mTc-DTPA among patients with obstructive uropathy.

# **METHODS**

A cross-sectional study was conducted for a period of one year between June 2016 and April 2017 in the department of urology at a Government medical college hospital in Tamil Nadu. The study was started after getting approval from the institutional ethical committee and the informed consent was obtained from all the study subjects involved

in the study. Patients who have been diagnosed as chronic unilateral renal obstruction and were requiring 99mTC-DTPA nuclear scan for functional assessment of kidneys were included as our study subjects. Patients with acute renal obstruction, bilateral renal obstruction and elevated renal parameters were excluded from the study. A nonrandomized purposive sampling technique was used to derive the sample and based on that all patients satisfying our inclusion and exclusion criteria and reporting to our department in the above mentioned study period were taken as our sample. A total of 46 patients were taken as our study sample. Patients with chronic unilateral renal obstruction who underwent DTPA renogram for functional evaluation were included in the study. The softcopy of their triphasic CECT KUB were collected. The processing of the contrast enhanced images of the kidney was done by a single radiologist. Arterial phase image was processed on advantage workstation (general electric Milwaukee, Wisconsin) version 4.6 which comes preinstalled with GE optima 660 128 slice CT machine. In the pre-installed software volume rendering of kidney tool alone was selected, whereas measurements related to renal pelvis and renal blood vessels were excluded and finally automatic volume calculation was done to obtain the volume percentage of each kidney. All the data were entered and analysed using SPSS version 24. The volume percentage that was obtained through CECT images was correlated with split renal function estimation done by <sup>99m</sup>TC-DTPA renal scan. Statistical inference was made based on the Pearson's correlation results.

#### **RESULTS**

In our study majority of the patients were in the age group between 20 and 40 years with a mean age of 32.7 years with a minimum age of 19 and a maximum age of 62 years. Male patients were slightly more in number than the females but no statistical significant difference was observed in the age group between males and females (p>0.05) (Table 1). Pelvi-ureteric junctional obstruction (PUJO) was found to be the most common cause for unilateral chronic obstructive uropathy in our study subjects, followed by ureteric and renal pelvic calculus and urteric stricture was found to be the cause only in 8.6% of the patients reported with chronic obstructive uropathy (Table 2). Regarding the side of the kidney involvement, 24 (52%) patients had right and 22 (48%) patients had left sided kidney involvement. The mean creatinine for the study subjects was 0.97±0.19 mg/dl. In our study only 12 patients (26%) had a history of recurrent unilateral renal obstruction for which surgical intervention was done. Among our patients, diabetes and hypertension was found to be the most common co-morbid conditions which were reported in nearly 25% of the study subjects (Table 3). The renal volume assessed by CECT and renal function measured by 99mTC-DTPA nuclear scan were measured in percentage and among the obstructed renal units the volume or functional assessment was made in the units of 0-40% at the interval of 10% and it was found that the number of patients detected in each interval was almost similar in both CECT and <sup>99m</sup>TC-DTPA scan and no statistical significant difference was observed in the detection of volume/renal function between the two groups (Table 4). Similarly for non-obstructed renal units the volume or functional assessment was made in the units of 60-100% at the interval of 10% and a similar type of result which was observed with obstructive renal units was seen with no statistical significant difference between the two groups in the detection of renal volume/renal function (Table 5).

In our study we found a strong positive linear correlation between the renal volume percentage estimated by CECT with the differential renal function estimated by the <sup>99m</sup>TC-DTPA renal scan both for obstructive and non-

obstructive renal units (r=0.904 and 0.889; p<0.001) (Table 6). For every 1% increase in levels percent renal volume CT in obstructed renal units there is a corresponding 0.29% increase in percent renal function <sup>99m</sup>TC-DTPA which is indicated by the linear correlation formula.

y=1.0222x-0.7345 (Figure 1).

Similarly for non-obstructed renal units for every 1% increase in levels of percent renal volume CT there is a corresponding 1.70% increase in percent renal function measured by <sup>99m</sup>TC-DTPA and this is indicated by the linear correlation formula,

y=1.0278x+0.6696 (Figure 2).

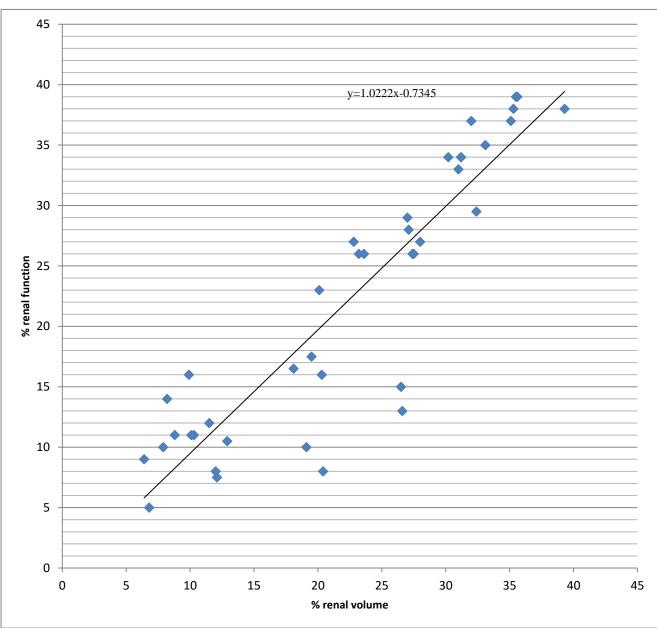


Figure 1: Percent renal volume versus percent renal function in obstructed renal units.

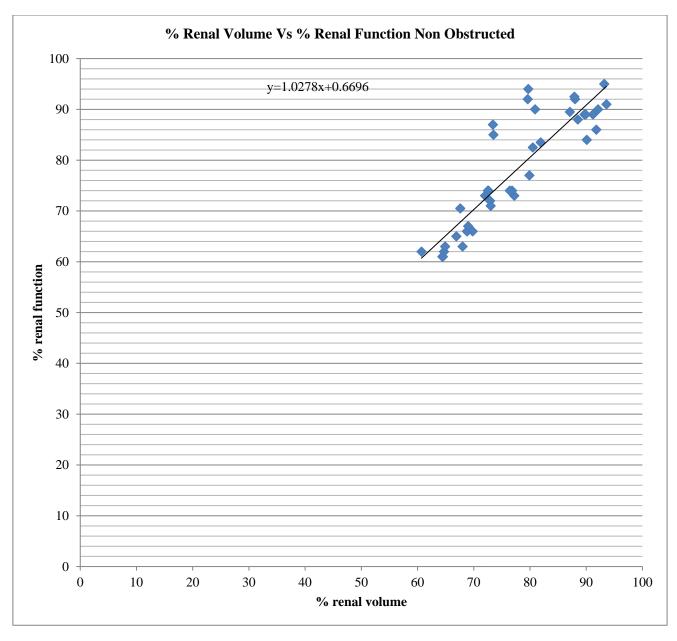


Figure 2: Percent renal volume versus percent renal function in non-obstructed renal units.

Table 1: Age and gender wise distribution of the study subjects.

Age groups (in years)	Male (%)	Female (%)	Total (%)	P value
<20	2 (8)	2 (9.5)	4 (8.6)	
21-30	9 (36)	3 (14.2)	12 (26)	
31-40	8 (32)	10 (47.6)	18 (39.1)	
41-50	4 (16)	3 (14.2)	7 (15.2)	0.714
51-60	1 (4)	2 (9.5)	3 (6.5)	0.714
>60	1 (4)	1 (4.7)	2 (4.3)	
Total	25 (100)	21 (100)	46 (100)	
Mean ±SD	33.1±9.7	32.9±8.9	32.7±10.2	

P value derived by using student t test.

Table 2: Distribution of the study subjects based on the etiology for chronic unilateral renal obstruction.

Etiology	Frequency	Percentage (%)
PUJO	19	41.3
Ureteric calculus	16	34.7
Renal pelvic calculus	7	15.2
Ureteric stricture	4	8.6
Total	46	100

PUJO-pelviureteric junction obstruction.

Table 3: Distribution of study subjects based on presence of chronic co-morbid conditions like diabetes and hypertension.

Co-morbid conditions	Frequency	Percentage (%)
Diabetes	9	19.5
Hypertension	12	26
Diabetes and hypertension	5	10.8

Table 4: Comparison of renal volume assessed by CECT and renal function assessed by <sup>99m</sup>TC-DTPA nuclear scan in obstructed renal units among study subjects.

% renal volume/renal function assessed by CECT/ <sup>99m</sup> TC-DTPA	CECT-frequency (%)	99mTC-DTPA-frequency (%)	r value	P value
≤10	7 (15.2)	8 (17.3)	_	0.817*
10.1-20	11 (23.9)	10 (21.7)		$0.808^{*}$
20.1-30	15 (32.6)	14 (30.4)		$0.814^{*}$
30.1-40	13 (28.2)	14 (30.4)		0.910*
Total	46 (100)	46 (100)		

<sup>\*=</sup>p value derived by applying Chi square test.

Table 5: Comparison of renal volume assessed by CECT and renal function assessed by <sup>99m</sup>TC-DTPA nuclear scan in non-obstructed renal units among study subjects.

% renal volume/renal function assessed by CECT/99mTC-DTPA	CECT-frequency (%)	99mTC-DTPA-frequency (%)	r value	P value
≤70	14 (30.4)	13 (28.2)		0.907*
70.1-80	15 (32.6)	12 (26)		0.718*
80.1-90	10 (21.7)	14 (30.4)		0.658*
>90	7 (15.2)	7 (15.2)		1.000*
Total	46 (100)	46 (100)		

<sup>\*=</sup>p value derived by applying Chi square test.

Table 6: Pearson correlation between CECT and DTPA nuclear scan for obstructed and non-obstructed renal units.

Variables	r value	P value
Obstructed renal units	0.904	< 0.0001
Non-obstructed renal units	0.889	< 0.0001

p value derived for Pearson's correlation test.

#### **DISCUSSION**

Obstructive uropathy is being considered as the most common urological problem which is encountered in our routine urological practise. The management of obstructive uropathy primarily depends on the cause of obstruction and the function of the two renal units. Chronic obstruction would lead onto hydronephrosis which finally ends up in renal cortical thinning.14 Thinning of cortex can cause gradual progressive deterioration of renal function of that involved renal unit. So early identification and appropriate management is warranted in patients with obstructive uropathy. Though radionuclear study being considered as the gold standard investigation in identification of obstructive uropathy as it does functional assessment of the renal units, but one of the problem encountered in it is, it lacks anatomical details and it is not universally available because of its huge cost.<sup>15</sup> So in order to overcome these pitfalls we conducted a study with an objective of assessment of CECT based renal parenchymal volume to be used for functional assessment of the kidney and correlate its findings with radionuclear study done with 99mTC-DTPA scan and if found successful the single multiparametric CECT can be used for both anatomical and functional evaluation of the renal units.

The mean age reported in our study was almost in par with the study conducted by In Maged et al and Sarma et al. 1,16 In our study the sex distribution had slight male preponderance, whereas in the study done by Sarma et al and Maged et al there was a slight female predominance.<sup>1,16</sup> In our study the most common etiology of the obstruction was the pelvicureteric junction obstruction followed by the ureteric calculus and renal pelvic calculus with a very minimal cases of ureteric stricture, whereas the studies done earlier had quoted ureteric and renal calculus as the most common cause followed by PUJO and ureteric stricture. The reason for less ureteric calculus cases in our study group might be due to the fact that the ureteric or renal calculus would produce acute pain that brings the patient early to the hospital for management.

In recent years, few studies have clearly demonstrated the use of CT to assess renal perfusion and GFR. Langheinrich et al demonstrated that GFR measurement can be made accurately using triphasic CT and further they found a strong linear relationship between differential renal function by dynamic CT using modified Patlak graphic analysis, nuclear renal scan and 24 hour creatinine clearance. In another study done by Herts et al who compared the estimated GFR by CT-based parenchymal volume with GFR measurement by 125I-iothalamate clearance imaging and found that CT was comparable to GFR assessment by nuclear medicine methods. Tel-Ghar et al in his study had quoted that contrast enhanced spiral CT was more sensitive than IVP for identifying the cause of chronic obstructive uropathy

and it was as accurate as radioisotope renal scan for calculating the total and separate kidney function.<sup>18</sup>

In 2016, Jacob et al investigated 49 patients with chronic unilateral obstruction and reported a strong correlation between CT and nuclear renography. Another study in 2014 by Hamed et al done on 42 patients and a recent study done in 2020 in China by Li et al among 76 patients with renal obstruction found a similar type of results, showing a positive linear correlation between CT and DTPA nuclear scan for assessing the renal function. 19,20

But despite the strong correlation between CT and DTPA scan for assessing renal functions in chronic renal obstruction which was indicated by studies conducted earlier as well as the current study, one of the major disadvantage in using CT is the need for contrast media administration which would adversely affect the renal functions. Another advantage of <sup>99m</sup>TC-DTPA renal scan over CT is the radiation exposure is much lower in DTPA scan compared to CT (10 mSv versus 1.8 mSv).

The only limitation of the present study was the sample size, but most of the studies done earlier also had the similar number of samples.

#### **CONCLUSION**

There is a statistically significant correlation between CT and DTPA renal scan for measuring the renal function in unilateral obstructive uropathy and so it can be safely inferred as CECT has high sensitivity in detecting anatomical and functional details and it can be used as an integrated modality in the assessment of unilateral renal obstruction. Though <sup>99m</sup>TC-DTPA renal scan is a safest choice by considering its less radiation exposure and no contrast requirement, still cost and its universal availability make us to consider CECT as a better alternative, but more comparative and prospective type of similar studies are warranted to substantiate our findings.

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Institutional Ethics Committee

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