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The Value of Tc-99mMDP Bone Scan in Assessment of Renal Functions in Urinary Tract Neoplasm Patients After Chemotherapy Compared to Tc-99mDTPA Renal Scan.

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ABSTRACT:

Aim: our study investigates the use Tc-^{99m}MDP for assessing GFR, split function and metastatic work-up in urinary tract neoplasm patients to replace separate Tc-^{99m}DTPA and Tc-^{99m}MDP studies with a single Tc-^{99m}MDP study, thereby reducing cost, time and radiation exposure. **Materials**: Fifty adult patients with malignant urinary tract tumors underwent Tc-^{99m}DTPA and Tc-^{99m}MDP scans within one week. Tc-^{99m}DTPA was administered at a 5 mCi for GFR measurement. For Tc-^{99m}MDP, 5 mCi was used for dynamic renography followed by 15 mCi for post-3-hour whole-body imaging. Regions of interest (ROIs) were defined around each kidney and a background region was placed inferior to each kidney. GFR and split function were determined by Gates' method. **Results**: the study demonstrated a strong positive correlation between Tc-^{99m}DTPA and Tc-^{99m}MDP measurements: total GFR (r= 0.981, p < 0.001), LT kidney GFR, (r = 0.959, p < 0.001), RT kidney GFR (r = 0.980, p < 0.001), LT kidney split function (r = 0.951, p < 0.001) RT kidney split function (r = 0.951, p < 0.001).

Conclusion: Tc-^{99m}MDP can be an alternative to Tc-^{99m}DTPA for evaluating renal function while conducting bone metastases surveys in patients with urinary tract malignancy, offering a more efficient approach with reduced cost and radiation exposure.

Keywords: GFR, split function, renal scan, bone scan, urinary tract neoplasms.

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INTRODUCTION:

Tc-^{99m} methylene diphosphonate (**Tc-^{99m}MDP**) is well established as a tracer for skeletal imaging for many years. The most common use is a screening test for the detection of bone metastases from malignant tumors. Patients with urinary tract malignant tumors are likely to have impaired renal function in addition to chemotherapy nephrotoxicity, so estimation of renal function with routine detection of bone metastases in these patients is indicated. [1] On the other hand, Tc-^{99m} Diethylene Triamine- Penta Acetic Acid (**Tc-^{99m}DTPA**) is the routine tracer for renal function assessment. The main required information in the renal scan is the total GFR and split function for each kidney. It is well known that Tc-^{99m}MDP is excreted through the kidneys with uro kinetics similar to Tc-^{99m}DTPA. So, it is very favorable from the viewpoint of convenience and cost effectiveness to use Tc-^{99m}MDP in both metastatic work-up and renal function assessment in one study.

The purpose of this study is to compare the GFR obtained with Tc-^{99m}MDP with those obtained with Tc-^{99m} DTPA and to investigate the potential utility of Tc-^{99m} MDP for the assessment of renal function.[2-5]

MATERIALS and METHODS:

The study included 50 patients (47 males and 3 females) with urinary tract neoplasms. Their ages ranged from 36 to 75 years (mean 63.84 ± 8.84), weight from 47 to 110 kg (mean 66.72 ± 14.42), height f-rom 150 to 180 cm (mean 164.30 ± 6.97, serum creatinine from 0.5 to 8.7mg/dL (mean 1.45± 1.53). All patients received chemotherapy and underwent both radionuclide studies with Tc-^{99m}DTPA and Tc-^{99m}MDP within a period of one week.

Renal scan with Tc-^{99m}DTPA: All patients were well-hydrated with 600-1000 ml of water before the examination. Rapid injection of 185 MBq (5mci) of Tc-^{99m}DTPA was given through an IV cannula and followed by infusion of 5 ml of normal saline. Counts in pre-injection and post-injection syringes were measured for 60 seconds at 30 cm from the Gamma-Camera, to determine the net amount of activity injected. Renography was carried out with the patient in a supine position with the gamma-camera detector placed under the patient's bed. Immediately after tracer arrival within the kidneys, data acquisition was performed for 11 minutes (1 sec per frame for 60 sec and 25 sec per frame for 600 sec) with a scintillation camera equipped with a general purpose, low energy parallel hole type collimator. A 20% energy window was centered on the 140 Kev photo peak. With a 64 x 64 matrix, serial interval dynamic images were recorded on radiographic film. [6-8]

Renal and skeletal imaging with Tc-^{99m}MDP: Imaging with Tc-^{99m}MDP was performed on another day. Each patient was hydrated with 600-1000 ml of water before the examination. Rapid injection of 185 MBq (5mCi) of Tc-^{99m}MDP was given through an IV cannula and followed by infusion of 5 ml of normal saline. The remaining 555 MBq (15 mCi) of the tracer was injected after finishing the dynamic study. The planner bone scan delayed images were done 3 hours after the second injection of Tc-^{99m}MDP using both anterior and posterior views with a matrix of 1042 x 256 and the window was centered at 140 Kev with 20% window. Patients asked to remove metals. Patients asked to lie supine with arms down and immobilized to minimize movement during acquisition. Whole body scan (table rate ~ 10-12 cm/min) was acquired. [(6-8)]

Data Analysis: ROIs were placed around each kidney, and a background region was placed inferior to each kidney. After background subtraction, time-activity curves were generated for both kidneys. Total GFR and split function of each kidney were obtained.[(6-8).]

Interpretation: Two experienced nuclear medicine physicians have read both modalities independently. Readers were informed about the clinical history and previous investigations of the patients. The GFR results obtained by Tc-99mMDP were compared with those obtained by of Tc-99mDTPA and the feasibility of the assessment of uro kinetics with Tc-99mMDP was investigated. The late images of bone scan with Tc-99mMDP interpreted for metastatic work-up as free, have single or multiple osseous deposits.

RESULTS:

This cross-sectional analytical study involved renal and bone scans of 50 patients including 47 males (94 %) and 3 females (6%). The correlation and linear regression analysis results for the relationship between DTPA total GFR and MDP total GFR indicate a strong positive correlation between the two variables (r = 0.981, p < 0.001), suggesting a significant relationship. The linear regression model shows that MDP total GFR has a strong positive effect on predicting DTPA total GFR, with a standardized coefficient (Beta) of 0.981. This indicates that for every unit increase in MDP total GFR, there is a corresponding increase of approximately 0.981 units in DTPA total GFR. The coefficient for MDP total GFR is statistically significant (p < 0.001), suggesting that it is a strong predictor of DTPA total GFR. The 95% confidence interval for the coefficient ranges from 0.953 to 1.068, providing a range of values within which we can be 95% confident that the true coefficient lies as shown in Table 1, Table 2 and Fig 1.

Table 1. Correlation between DTPA and MDP total GFR

		DTPA total GFR
MDP total GFR	r	0.981
	P value	< 0.001
	N	50

Table 2. Linear regression model for prediction of DTPA total GFR

Model		Unstandardized Coefficients		Standardized Coefficients	t	P value	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
DTPA total GFR	Constant	-1.380-	1.724		-0.800-	0.428	-4.847-	2.087
	MDP total GFR	1.011	0.029	0.981	35.352	<0.001	0.953	1.068

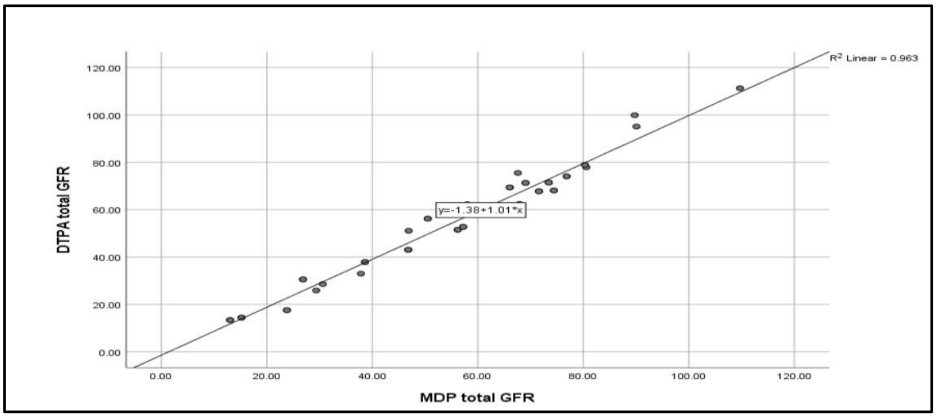

Fig 1. The relationship between total GFR for the two tracers

The linear regression model reveals that MDP LT kidney GFR has a strong positive effect on predicting DTPA LT kidney GFR, with a standardized coefficient (Beta) of 0.959. This indicates that for every unit increase in MDP LT kidney GFR, there is a corresponding increase of approximately 0.959 units in DTPA LT kidney GFR. The coefficient for MDP LT kidney GFR is 0.982, with a standard error of 0.042. The t-value for MDP LT kidney GFR is 23.565, with a highly significant p-value of <0.001. This indicates that the coefficient for MDP LT kidney GFR is statistically significant, suggesting that it is a strong predictor of DTPA LT kidney GFR. The 95% confidence interval for the coefficient of MDP LT kidney GFR ranges from 0.898 to 1.066. This interval provides a range of values within which we can be 95% confident that the true coefficient lies as mentioned in Table 3, Table 4 and Fig 2.

Table 3. Left kidney GFR

		DTPA LT kidney GFR
MDP LT kidney GFR	r	0.959
	P value	< 0.001
	N	50

Table 4. Linear regression model for prediction of DTPA left kidney GFR

Model		Unstandardized Coefficients		Standardized Coefficients	t	P value	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
DTPA LT kidney GFR	Constant	0.287	1.169		0.245	0.807	-2.064-	2.638
	MDP LT kidney GFR	0.982	0.042	0.959	23.565	<0.001	0.898	1.066

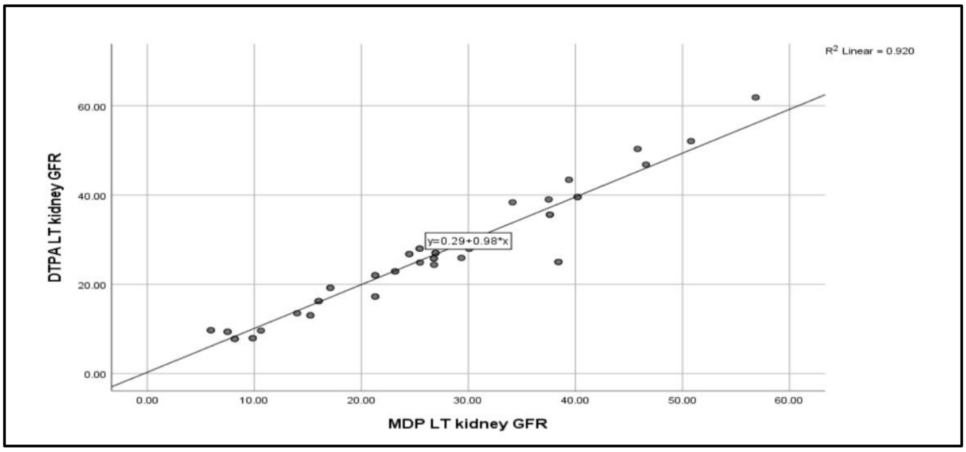

Fig 2. The relationship between the left kidney GFR for the two tracers

The linear regression model reveals that MDP Right kidney GFR has a strong positive effect on predicting DTPA Right kidney GFR, with a standardized coefficient (Beta) of 0.980. This indicates that for every unit increase in MDP Right kidney GFR, there is a corresponding increase of approximately 0.980 units in DTPA Right kidney GFR. The coefficient for MDP Right kidney GFR is 1.021, with a standard error of 0.030. The t-value for MDP Right kidney GFR is 33.886, with a highly significant p-value of <0.001. This indicates that the coefficient for MDP Right kidney GFR is statistically significant, suggesting that it is a strong predictor of DTPA Right kidney GFR. The 95% confidence interval for the coefficient of MDP Right kidney GFR ranges from 0.961 to 1.082. This interval provides a range of values within which we can be 95% confident that the true coefficient lies as demonstrated in table 5, table 6 and Fig 3

Table 5. Right kidney GFR

		DTPA Right kidney GFR
MDP Right kidney GFR	r	0.980
	P value	< 0.001
	N	50

Table 6. Linear regression model for prediction of DTPA right kidney GFR

Model		Unstandardized Coefficients		Standardized Coefficients	t	P value	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
DTPA Right kidney GFR	Constant	-1.245-	1.048		- 1.188-	0.241	-3.353-	0.862
	MDP Right kidney GFR	1.021	0.030	0.980	33.886	<0.001	0.961	1.082

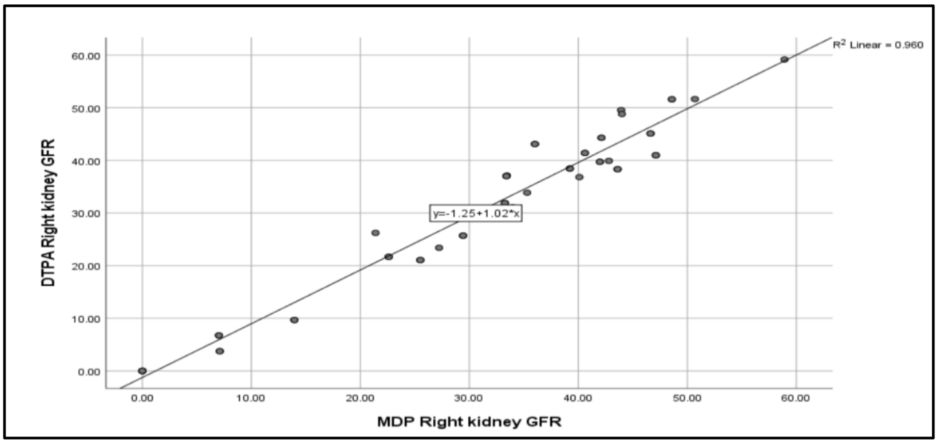

Fig 3. The relationship between the right kidney GFR for the two tracers

The linear regression model shows that MDP left split function % has a strong positive effect on predicting DTPA left split function %, with a standardized coefficient (Beta) of 0.951. This indicates that for every unit increase in MDP left split function %, there is a corresponding increase of approximately 0.951 units in DTPA left split function %. The coefficient for MDP left split function % is 0.979, with a standard error of 0.046. The t-value for MDP left split function % is 21.288, with a highly significant p-value of <0.001. This indicates that the coefficient for MDP left split function % is statistically significant, suggesting that it is a strong predictor of DTPA left split function %. The 95% confidence interval for the coefficient of MDP left split function % ranges from 0.886 to 1.071. This interval provides a range of values within which we can be 95% confident that the true coefficient lies as provided in table 7, table 8 and Fig.4

Table 7. Left kidney split function

		DTPA left split function %
MDP left split function %	r	0.951
	P value	< 0.001
	N	50

Table 8. Linear regression model for prediction of DTPA left split function%

Model		Unstandardized Coefficients		Standardized Coefficients	t	P value	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
DTPA left split function %	Constant	2.140	2.356		0.909	0.368	-2.596-	6.877
	MDP left split function %	0.979	0.046	0.951	21.288	<0.001	0.886	1.071

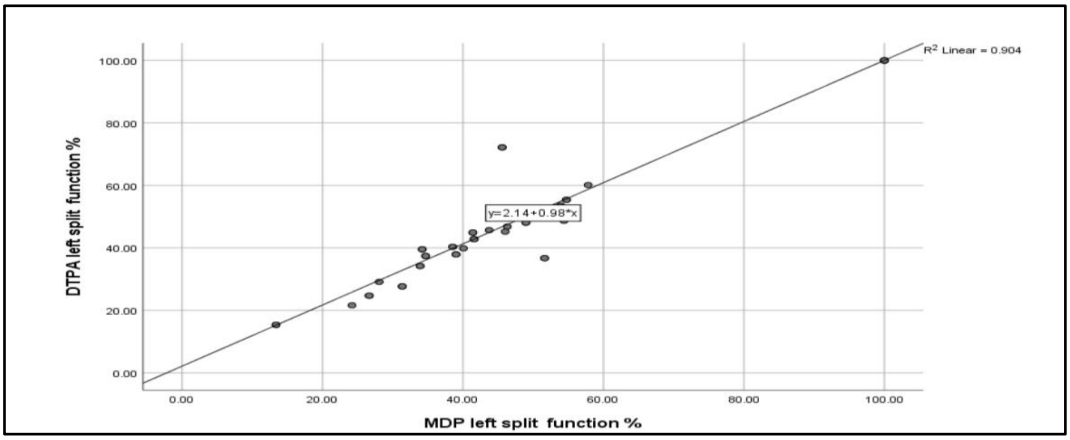

Fig 4. The relationship between the left kidney split function for the two tracers

The linear regression model suggests that MDP right split function % is a robust predictor of DTPA Right split function %. The standardized coefficient (Beta) of 0.951 indicates that for each unit increase in MDP right split function %, there is an estimated increase of approximately 0.951 units in DTPA Right split function %. The coefficient for MDP right split function % is 0.979 with a standard error of 0.046. The high t-value of 21.288 and a very low p-value of <0.001 indicate that the coefficient for MDP right split function % is statistically significant. These results suggest that MDP right split function % serves as a valuable predictor for estimating DTPA Right split function % in the studied population. The 95% confidence interval for the coefficient of MDP right split function % ranges from 0.886 to 1.071. This interval provides a range of values within which we can be 95% confident that the true coefficient lies as demonstrated in table 9, table 10 and Fig 5.

Table 9. Right kidney split function

		DTPA right split function %
MDP right split function %	r	0.951
	P value	< 0.001
	N	50

Table 10. Linear regression model for prediction of DTPA right split function%

Model		Unstandardized Coefficients		Standardized Coefficients	t	P value	95% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
DTPA Right split function %	Constant	-0.030-	2.605		-0.012-	0.991	-5.267-	5.207
	MDP right split function %	0.979	0.046	0.951	21.288	<0.001	0.886	1.071

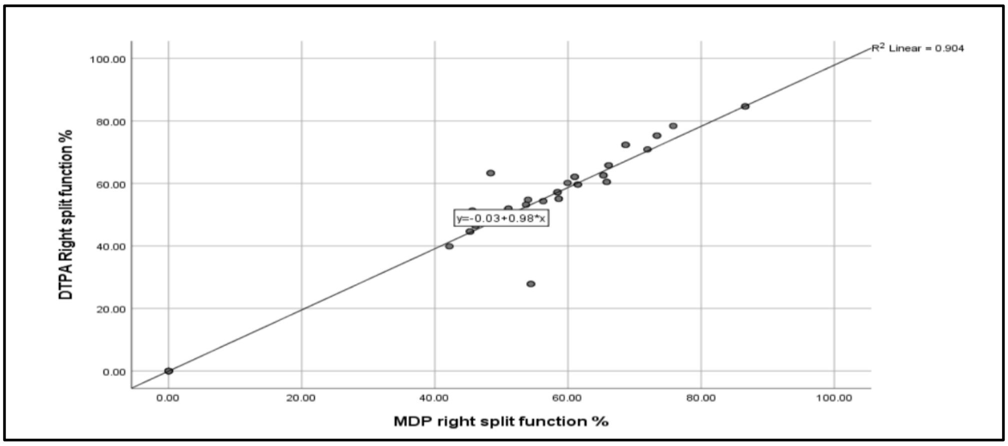

Fig.5 The relationship between the right kidney split function for the two tracers

DISCUSSION:

We conducted a cross sectional analytical study to assess the feasibility of using Tc-^{99m}MDP to evaluate renal function incidental to the survey of bone metastases in patients with urinary tract malignant tumors. To explore the feasibility of assessing renal function with Tc-^{99m}MDP, the glomerular filtration rate (GFR) obtained using Tc-^{99m}MDP must be compared with that obtained using Tc-^{99m}DTPA and the correlation between the GFR values obtained by the two methods is calculated. Gate's method is the most commonly used gamma camera-based for GFR calculations. To calculate GFR, the percentage uptake of the radionuclide in the kidneys 2 to 3 minutes after its appearance is used. This technique provided incidental information about renal morphology and function during bone scintigraphy with Tc-^{99m}MDP.

In current study we found that **total GFR** using DTPA was 55.44 ± 22.71 ranging from 13.44 to 111.23 ml/min while total GFR using MDP was 56.21± 22.05 ranges from 13.04 to 109.71 ml/min. The relationship between DTPA total GFR and MDP total GFR indicates a strong positive correlation between the two variables (r = 0.981, p < 0.001), suggesting a significant relationship. These results were agreed with results obtained by **Saif Elden et al, 2014** that showed, total GFR obtained by Tc-^{99m}MDP correlated well with those obtained by 99mTc-DTPA (r=0.83, p<0.002).[6] and almost the same results reported by **Khalil et al**, that showed (r=0.96, p<0.001)[7] **as well as (Teruhiko Takayama et al, 2001)** that showed (r=0.92, p<0.001)[8]. **Left kidney GFR** using DTPA was 25.08 ± 12.66 ranging from 7.76 to 61.86 ml/min while the left kidney GFR using MDP was 25.25 ± 12.37 ranging from 5.94 to 56.84 ml/min. The relationship between DTPA LT kidney GFR and MDP LT kidney GFR indicates a strong positive correlation between the two variables (r = 0.959, p < 0.001), suggesting a significant relationship which is almost the same results obtained by **Saif Elden et al,** (r=0.96, p<0.001)[6] and largely consistent with that obtained by **Khalil et al**, (r=0.973, p<0.001).[7] **Right kidney GFR** using DTPA was 30.37 ± 16.69 ranging from 0.00 to 59.16 ml/min while the right kidney GFR using MDP was 30.96 ± 16.02 ranging from 0.00 to 58.91.The relationship between DTPA RT kidney GFR and MDP RT kidney GFR indicates a strong positive correlation between the two variables (r = 0.980, p < 0.001), suggesting a significant relationship which is a little bit different from that obtained by **Saif Elden et al,** (r=0.76, p<0.008)[6] and largely consistent with that obtained by **(Khalil et al**,(r=0.98, p<0.001).[7] Our split GFR results are comparable with those obtained by **(Teruhiko Takayama et al** that revealed a correlation coefficient of (r= 0.944, p<0.001).[8] In the current study we found the **left split** obtained by Tc-^{99m}MDP correlated well with those obtained by Tc-^{99m}DTPA (r = 0.951, p < 0.001). This result indicates a strong positive linear relationship and largely consistent with that obtained by **Saif Elden et al,** (r=0.96, p<0.001).[6] While we found the **right split** obtained by Tc-^{99m}MDP correlated well with those obtained by Tc-^{99m}DTPA (r = 0.951, p < 0.001). This result indicates a strong positive linear relationship and largely consistent with that obtained by **Saif Elden et al**, (r=0.96, p<0.001).[6]

CONCLUSION:

The assessment of renal function with Tc-^{99m}MDP can be performed incidental to bone scintigraphy and is expected to provide useful information in monitoring renal function. The early characteristics of renal handling of Tc-^{99m}MDP are sufficiently similar to those of Tc-^{99m}DTPA with the installation of the quantity of radiopharmaceuticals for two tracers. So that accurate estimation of differential (split) renal function is possible with this agent, and that Tc-^{99m}MDP determined renal differential most likely reflects differential glomerular filtration rate.

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