Original article

Comparison of the Relative Renal Function Calculated with 99mTc-Diethylenetriaminepentaacetic Acid and 99mTc-Dimercaptosuccinic Acid in Children

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Abstract

The aim was to compare the relative renal functions measured with technetium-99m dimercaptosuccinic acid (99mTc-DMSA) and technetium-99m diethylenetriaminepentaacetic acid (99mTc-DTPA) in children with renal diseases. Relative renal function of 128 children who applied to three hospitals from 2009 to 2011 were analyzed retrospectively. The mean value measured with 99mTc-DTPA and 99mTc-DMSA were 51.58 ± 14.95 and 51.96 ± 14.99 for the right kidney, 47.87 ± 15.27 and 47.94 ± 15.17 for the left kidney, respectively. A significant positive correlation was found between the relative renal functions (r = 0.963, P < 0.001). In Bland-Altman plots, the mean difference between two methods was 0.7 and the correlation limits were between 10.1 and-10.8. As a result, although 99mTc-DMSA is accepted as the most reliable method for the determination of relative renal function, 99mTc-DTPA can be another choice for the calculation of relative renal function without a complementary DMSA scan particularly in pediatric patients who require renogram curve and GFR calculations.

Keywords: Child, relative renal function, technetium-99m diethylenetriaminepentaacetic acid, technetium-99m dimercaptosuccinic acid

Introduction

Renal scintigraphy has been used to measure the relative renal function for a long time. Different radiopharmaceuticals such as technetium-99m dimercaptosuccinic acid (99mTc-DMSA), technetium-99m diethylenetriaminepentaacetic acid (99mTc-DTPA), technetium-99m mercaptoacetyltriglycine (99mTc-MAG3), Iodine 131 orthoiodohippurate and more recently technetium-99 m ethylenedicysteine (99mTc-EC) were used.[1] All of them can be used accurately to measure the relative renal function, although there are some differences among these radiopharmaceuticals.[2] These differences are due to distinct biological properties of radiopharmaceuticals such as mechanisms of renal excretion, renal cell retention of radioactive material, level of plasma-protein bound and level of plasma clearance. However, 99mTc-DMSA as a static renal agent is considered the most reliable method to measure relative renal function and the most appropriate tracer for renal cortical imaging.[3-6] 99mTc-DMSA binding level to protein in mammals is 90%, this binding prevents significant glomerular filtration and 99mTc-DMSA primarily enters the kidney via peritubular extraction.[7] It is primarily used in humans for cortical imaging and estimation of functional renal mass.[8-10] Applications in humans include detection of pyelonephritis and renal scars[11-13]

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99mTc-DTPA is used for glomerular filtration rate (GFR) evaluation in mammals because no tubular secretion or reabsorption is observed but it is throughly filtered by the glomerulus.[8,10-14] There are many studies in literature comparing relative renal function calculated with 99mTc-DTPA and 99mTc-DMSA in adults and children. In some papers, it is emphasized that relative renal function calculated with 99mTc-DTPA is as reliable as 99mTc-DMSA.[15] On the other hand, in some of the studies, it is mentioned that 99mTc-DTPA is not as good as 99mTc-DMSA in relative renal function calculation.[16,17] As there is ambiguity in the reliability of 99mTc-DTPA for the calculation of relative renal function and there are limited study related to relative renal function calculation only in children; we retrospectively designed a study to compare the relative renal functions measured with 99mTc-DMSA and 99mTc-DTPA in pediatric patients with renal diseases.

Materials and Methods

We retrospectively analyzed a total of 128 children who were consulted to the Nuclear Medicine Departments of three hospitals between 2009 and 2011 and who had both dynamic and static renal imaging. Renal dynamic scintigraphies performed with 99mTc-DTPA were compared with the relative function measured using 99mTc-DMSA static scintigraphy. There were at least 2 days between two methods and not more than a week. The data analyzes were done by a nuclear medicine physician in each nuclear medicine departments.

99mTc-DTPA dynamic images were acquired with the patient in the supine position and the detector of gamma camera placed at the posterior plane. The cameras (Symbia S [Siemens, Germany], E-cam [Siemens, USA], Brightview [Philips, USA]) were equipped with an all-purpose, low energy, parallel-hole collimator. All patients were injected with 200 μCi/kg (at least 2 mCi) of 99mTc-DTPA and dynamic images were recorded in a 128 × 128 matrix format every second for 1 min and every 30 s for 20 min. Relative renal function was measured in a composite image (1-3 min after the injection). Renal and semilunar background regions of interest (ROIs) were drawn manually by a nuclear medicine physician. 99mTc-DMSA static images were acquired with the patient in the supine position. All patients were injected with 37-111 MBq of the radiopharmaceutical and static images were acquired in 256 × 256 matrix after 4 h in the posterior, left and right posterior oblique projections (250 kcounts/view or 5 min/view). Relative renal function was measured using the drawing ROIs of each kidney in the posterior image with background correction made by drawing a perirenal background around each kidney by a nuclear medicine physician.[18]

Comparison of relative renal function measurement using 99mTc-DTPA dynamic renal scintigraphy and 99mTc-DMSA static scintigraphy was performed by bivariate correlation (Pearson) analysis and Kruskal Wallis test. The comparison results were expressed with Bland-Altman analysis. The statistical analysis was carried out using the Statistical Package for the Social Sciences version 13 (SPSS, Chicago, IL).

Results

The hospital records of 128 children in three different centers were reviewed and the results of all the patients' kidney functions were analyzed. Fifty six of the patients were male when 77 of them were female. The age of the cases ranged between 2 and 16 and the mean age was 10.66 ± 4.2 years. Forty three patients had hydronephrosis, 53 had pyelonefritis, 13 had renal calculi, 4 had renal atrophy and 15 of them presented vesicoureteral reflux. Positive correlation was found between the 99mTc-DTPA and 99mTc-DMSA for the evaluation of relative kidney function in Pearson correlation test ($r = 0.963$, $P < 0.001$). In Bland-Altman analysis, the mean difference between these two methods was found 0.7 when confidence limits were between 10.1 and 10.8.

The mean relative renal functions measured with 99mTc-DTPA and 99mTc-DMSA were 51.58 ± 14. 95 and 51.96 ± 14.99 for the right kidney, 47.87 ± 15.27 and 47.94 ± 15.17% for the left kidney, respectively. In Pearson analysis a significant positive correlation was found between the relative renal functions calculated with 99mTc-DTPA and 99mTc-DMSA ($r = 0.963$, $P < 0.001$). When the data were analyzed with Kruskal Wallis test according the patients diagnosis, we did not find any difference between relative renal function calculated with both imaging methods ($P = 0.688$ for right and $P = 0.720$ left kidney with Tc-99m DMSA, $P = 0.756$ for right and $P = 0.720$ left kidney with Tc-99m DTPA) [Table 1]. In Bland-Altman plots, the mean difference between two methods was 0.7 and the correlation limits were between 10.8 and − 10.1. Some values were out of the range; these were mostly related to atrophic kidneys with lower split renal function in 99mTc-DMSA [Figures 1 and 2].

Discussion

Although there are many studies comparing the relative renal function calculation results of 99mTc-DTPA and 99mTc-DMSA, in published data research we could not find any studies comparing the results of the relative renal function measurement with 99mTc-DTPA and 99mTc-DMSA exclusively in the pediatric age group. The previous studies were performed in group of patients including adults and pediatric cases.

Table 1: The mean, maximum and minimum (%) values of relative renal function calculated for each disease

	DMSAR	DMSAL	DTPAR	DTPAL
Hydronephrosis				
Mean	52.360	47.616	52.651	47.349
N	43	43	43	43
SD	13.7656	13.7589	14.0524	14.0524
Minimum	14.0	13.0	16.0	11.5
Maximum	87.0	86.0	88.5	84.0
Infection				
Mean	53.245	46.755	52.121	46.785
N	53	53	53	53
SD	14.3757	14.3757	14.2802	14.6189
Minimum	10.0	7.0	10.0	6.0
Maximum	93.0	90.0	94.0	90.0
Stone				
Mean	50.154	49.077	50.154	49.000
N	13	13	13	13
SD	19.0519	20.5850	19.1522	20.5670
Minimum	26.0	8.0	26.0	6.0
Maximum	92.0	74.0	94.0	74.0
Renal atrophy				
Mean	42.750	57.250	42.750	57.250
N	4	4	4	4
SD	29.8482	29.8482	29.5000	29.5000
Minimum	3.0	25.0	3.0	26.0
Maximum	75.0	97.0	74.0	97.0
Reflux				
Mean	50.333	49.667	50.267	49.733
N	15	15	15	15
SD	12.7988	12.7988	12.1109	12.1109
Minimum	33.0	28.0	33.0	28.0
Maximum	72.0	67.0	72.0	67.0
Total				
Mean	51.965	47.949	51.589	47.872
N	128	128	128	128
SD	14.9915	15.1723	14.9521	15.2774
Minimum	3.0	7.0	3.0	6.0
Maximum	93.0	97.0	94.0	97.0
P	0.688	0.720	0.756	0.720

SD: Standard deviation; DTPAR: Diethylene triamine penta-acetic

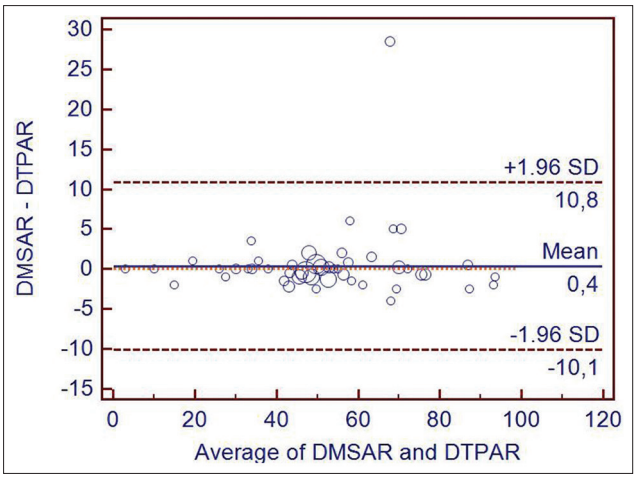

Figure 1: Bland-Altman plot of dimercaptosuccinic acid and diethylenetriaminepentaacetic acid for right kidney

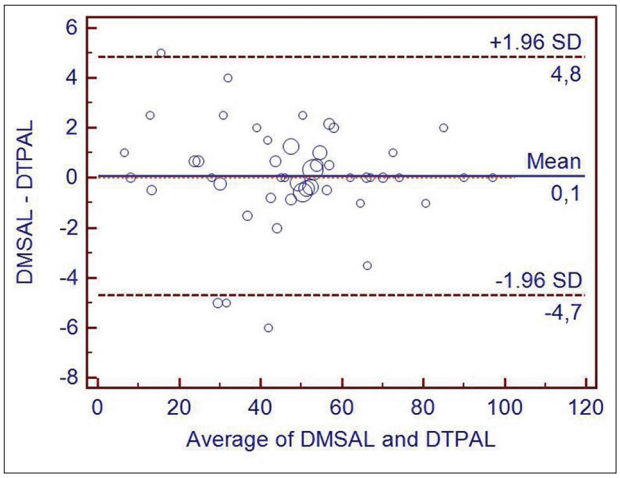

Figure 2: Bland-Altman plot of dimercaptosuccinic acid and diethylenetriaminepentaacetic acid for left kidney

Itoh *et al*.[17] discussed the correlation between 99mTc-DMSA and 99mTc-DTPA in renal uptake and they reported a good correlation between the relative renal uptake of 99mTc-DMSA (2 h) and that of 99mTc-DTPA (2-3 min).

In their study, Taylor *et al*.[19] compared the relative renal uptake of Tc-99m DMSA with the relative GFR and reported that the two methods of determining relative DTPA uptake showed excellent correlation.

A similar study reported by Domingues *et al*.[16] suggested that relative renal function measured with 99mTc-DTPA is different from that measured with 99mTc-DMSA with a marginal statistical significance. In their study the relative renal functions calculated with 99mTc-DTPA and 99mTc-EC was compared with the results of 99mTc-DMSA. They concluded that relative renal function measured with 99mTc-EC is comparable to 99mTc-DMSA results, but the results of relative renal function measured with 99mTc-DTPA was statistically different.

In a study of Lee *et al*.[15] calculated the relative renal function in 18 rabbits with unilateral ureteral obstruction. All the rabbits were imaged with 99mTc- DMSA and 99mTc-DTPA or 99mTc-MAG-3. They were no statistical differences between the groups, althoug there were differences between left and right kidneys. In conclusion of the study Lee *et al* stated that they concluded that dynamic renal imaging agents (99mTc- DTPA and 99mTc-MAG-3) could be performed instead of the static image of 99mTc-DMSA.

Ajdinović *et al*.[20] studied 24 infants presented with antenatal hydronephrosis in the newborn period with

renal scintigraphy. Ten patients with vesicoureteral reflux documented on micturating cystourethrography underwent 99mTc-DMSA renal scintigraphy and 14 patients were subjected to 99mTc-DTPA scintigraphy. They concluded that high percent of abnormal renal scintigraphy findings was obtained and renal scintigraphy was useful in the determination of the underlying cause of antenatally detected hydronephrosis.

In a different study[18] in adult's patients, they concluded that 99mTc-DTPA can be used in adult patients in whom GFR is important. In this situation the patient's radiation doses will be reduced by only using 99mTc-DTPA in the calculation of relative renal function.

In our study, we compared relative renal functions calculated with 99mTc-DTPA and 99mTc-DMSA in 128 pediatric cases. We have found a positive correlation between calculations in 99mTc-DTPA and 99 mTc-DMSA studies ($r = 0.937$, $P < 0.001$). Our study group consisted mostly of patients with diseases in which GRF and renogram curves were as important as relative renal function.

Even 99m Tc-DMSA is an inexpensive and easy method[22] used for cortical morphology and renal scar evaluation, patients who need the GFR and renogram curve results, the relative renal function calculated with 99mTc-DTPA may be used instead of static renal imaging with 99mTc-DMSA, since the comparison of the relative renal function results of 99mTc-DMSA and 99mTc-DTPA shows no statistical difference. In our study, there were some values out of range in Bland-Altman plots. These kidneys were mostly atrophic. In correlation to related literature results we thought that the difference between two methods was related to the depth and location of the renal tissue.[23,24]

Study limitations

Reproducibility analysis should be done in multicen-tere studies. In different centres the differences of relative renal function calculations with 99mTc-DMSA could be variate. But this is hard practically and ethically to do in human studies. So we could not able to perform this analise in our study.

Conclusion

As a result, we concluded that in relative renal function evaluation 99mTc-DTPA is reliable methods as 99mTc-DMSA scan. For patients who needs renogram curve and GFR calculations 99mTc-DTPA could be a choice for the calculation of relative renal function althoug 99mTc- DMSA is the gold standard method for the calcula-tion of relative renal function.

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