

## Evaluation of Individual Renal Function Using Tc 99m DMSA Scintigraphy in Children with Urinary Tract Infection

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### Introduction

It is generally accepted that DMSA scan is the best choice for evaluating renal scars therefore is included in almost all recommended algorithms for work-up of children with urinary tract infection (UTI). Fixation of the radioactive agent in the proximal tubular cells makes Tc 99m DMSA suitable for assessment of the functioning mass of the cortex. Evaluation of individual kidney function is possible by quantification of cortical activity, on delayed static images, after complete disappearance of radiopharmaceutical from the collecting system. Goldraich et al (1, 2) have shown that absolute quantification in kidneys is possible after 6 h of intravenous injection, when the uptake reaches a plateau. Gordon et al. (3) carried out studies on children and found that normal uptake at 6 h varied between 20-30% of injected dose. It is common to perform the study 24 h after the injection, when interference of "background" activity is negligible.

There are a number of studies where anatomic aspects of DMSA scan have been discussed, and only a few where functional data have been evaluated (1,2,3,4,5,6,7,8).

We have designed this study to evaluate clinical applicability and significance of the functional study with DMSA in management of children with UTI and sustained renal parenchymal damage, with or without vesicoureteric reflux (VUR).

The aims of the study were as follows: firstly to determine values for absolute uptake of DMSA in normal kidneys, in children. Secondly to assess whether significant differences in absolute uptake are present in kidneys which on DMSA have been presented as "morphologically abnormal" and those which have been declared as "normal".

### Patients and Methods

Inclusion criteria were at least one episode of urinary tract infection and no obstructive uropathy on ultrasonography. As a part of the clinical workup for children with UTI, Tc 99m DMSA scintigraphy was performed for evaluating renal parenchymal damage and direct cystographic study (radionuclide or radioologic) for detection of VUR. Control group consisted of children who have "no structural and functional abnormalities" by ultrasonography, scintigraphy and cystography.

Cortical scintigraphy with Tc 99m DMSA: images in PA, right and left oblique view were taken 2 hours after intravenous application of Tc 99m DMSA in a dose of 37-74mBq.

Scar was described as a defect in a kidney contour, with reduction of uptake of DMSA. Reflux nephropathy was diagnosed if there were scars and /or global contraction of kidney. Depending of findings nephroureteral units were classified as normal or abnormal. For describing abnormal findings on DMSA, modified Smellie's classification was used (9):

type 1- no more than 2 scars

type 2-more than 2 scars, with regions of normal kidney parenchyma

type 3-global kidney contraction, similar to obstructive nephropathy

type 4-shrunk kidney with reduction of kidney function to less than 10%

Individual renal function was assessed by quantification of absolute uptake of DMSA on delayed images 24 hours after injection. Percent of fixation is calculated from the number of impulses in the regions of kidneys (No), with correction for font, attenuation and disintegration. Factor for attenuation correction was calculated depending to the depth of the kidney (D), calculated from body surface A (sm<sup>2</sup>), according the formula:

$D = 2.82 A + 1.42$  (sm.) Real number of impulses was calculated using the formula  $N = No \exp. (-Db)$ , where b, linear coefficient of absorption for Tc 99m is  $b = 0.99$ . To assess whether renal indices can be used as a valuable indicator of individual function in kidneys with sustained parenchymal damage, we have compared the mean absolute uptake in kidneys presented on DMSA as "unilaterally abnormal", in contralateral healthy side and in control group. For describing statistically significant difference Student test has been used ( $P < 0.001$ ).

### Results

Cortical scintigraphy with Tc 99m DMSA have been performed in 211 children

(422 kidneys) with UTI. DMSA abnormalities were noticed in 67 kidneys: focal damage (scars) in 37 and global contraction in 30. The quantification of absolute uptake of DMSA has been made in 124 children (248 kidneys). Control group consisted of 41 children (82 kidneys). The values obtained in a control group were as follows: left 21.134(SD=6.487) right=21.151(SD=5.955) both 42.285 %

SD 12.149). Differential renal function for the left kidney was 49.864 (SD 3.18).

Results of comparative study between mean individual renal indices in unilaterally abnormal DMSA kidneys, contra lateral normal kidneys and control group are presented on Table 1. There is a significant difference between values of absolute uptake obtained in kidneys classified as type 2, 3, and 4 and control group, but the difference is not significant for kidneys classified as type 1. The mean absolute uptake obtained in contralateral healthy kidneys is higher then corresponding value in control group, but there is no statistically significant difference.

**Table 1. Absolute percent of DMSA uptake in kidneys with unilateral abnormal DMSA and contralateral normal kidneys compared with a control group**

	% of fixation of Tc 99m DMSA	
Number of kidneys	Abnormal DMSA	Contralateral side
Type 1 (n=14)	19.536 (SD=9.035)	22.507 (SD=11.092)
Type 2 (n=5)	13.42 (SD=4.145)	27.74 (SD=7.020)
Type 3 (n=12)	12.783 (SD=6.021)	23.142 (SD=6.421)
Type 4 (n=3)	7 (SD=5.903)	27.467 (SD=5.212)
Control group (n=82)	21.143 (SD=6.186)	

Student - test

Abnormal DMSA:

Type1/Contr.gr p>0.05;  
 Type2/Contr.gr. p<0.01;  
 Type3/Contr. gr. p<0.01;  
 Type 4/Contr.gr. p< 0.01;

Contralateral side:

Type 1/Contr.gr.p >0.05;  
 Type 2/Contr.gr.p<0.05;  
 Type 3/Contr.gr p >0.05;  
 Type4/Contr. gr.p<0.05

**Discussion**

Several authors have reported that relative uptake of DMSA is a very good index of differential kidney function and renal plasma flow (4, 5, 6, 7, 8). A good correlation between differential function obtained by Tc 99m DTPA and Tc 99m DMSA have been reported (7). In his instructive paper Gordon (3) determines normal ranges of both relative and absolute Tc 99m DMSA uptake in children. He points that a calculation of absolute uptake should include evaluation of number of variables, such as are: depth and background correction and preparation of Tc 99m DMSA. The presence of free technetium can compromise the final results. However, in the presence of obstructive uropathies results are not valid: DMSA may accumulate in the pelvis and result in a falsely high function to the hydronephrotic kidney. This effect can be exceeded by delaying the imaging, 24 h after injection. This might be a problem for a child and parents who should come again in the hospital the next day, and might

induce additional psychological trauma and burden of familiar budget.

Gordon (3) found that normal value for absolute uptake in children is as follows: left kidney 22.7(SD=2.3), right 21.4 (SD=2.0) and total 44.1 (SD 3.7).The mean differential function of the left kidney was 50% (SD 3.7).

Our results obtained in control group are comparable: left kidney 21.134 (SD=6.487), right 21.151(SD=5.955) total 42.285 (SD=12.149).The mean differential function of the left kidney 49.22% (SD=3.7).

The most important indication for DMSA scan in children with UTI is to detect renal parenchymal damage. In children the kidneys are growing and when a change in the differential renal function is observed on sequential Tc 99m DMSA scans it is important to known weather one is deteriorating or the other is showing compensatory hypertrophy. Quantification of the percentage of the injected dose taken up by kidney allows this crucial distinction to be made (3).

Aperia an al (9) have measured clarence of inulin and tubular reabsorption of glucose and have shown that in children with low grade and mild vesicoureteric reflux, were normal, but in children with high grade VUR, functional disturbances were noticed. They have not analyzed the findings concerning of presence or absence of scars. Verier Jones and al (10) have been examined glomerular filtration in school girls with asymptomatic bacteriuria, using Tc 99m DTPA for to asses the effects of bacteriuria, VUR and scars on glomerular filtration rate. They have shown significant difference between GFR in kidneys with and without reflux. In kidneys which on urography were declared as "normal", mean GFR was significantly grater (about 50%), then in kidneys affected by scaring process. They have concluded that the difference in GFR have depended more of presence or absence of reflux nephropathy, then of effect of the vesicoureteric reflux, alone. When they evaluated total GFR for both kidneys they noticed that effect of scaring on GFR at least in a part was masked from compensatory hypertrophy on contralateral side.

Goldraich an al (1, 2) have examined individual renal function, determining absolute percent of fixation of DMSA. In a study of 210 refluxing kidneys, they have noticed functional damage in 25% in a time when reflux was detected. In the following study they have examined 300 kidneys with VUR in 203 children and have shown that when kidneys on DMSA were classified as "normal", a functional index was normal or higher. When scaring was present, functional index can be normal, higher or lower.

Results in our study are similar. Analyzing the values of functional index in kidneys with unilateral abnormal DMSA scan, in comparison with corespondent values in control group, we noticed significant difference in kidneys classified as type 2, type 3 and type 4. In kidneys classified as type 1 (up to 2 scars) the difference was not significant

In contralateral kidneys mean values of absolute uptake were higher, although the difference was no significant. We should be careful in interpretation of the results we have obtained, considering the complexity of interrelationship which can interfere in kidneys affected by the process of

scaring. For compensation of the effect of loss of renal parenchyma it is possible that hypertrophy of the rounding normal renal parenchyma have supervened, on the affected or contralateral side. In this aspect, our results in "type 1" group which do not significantly differ from normal, support the concept that eventual compensatory hypertrophy might mask the effect of renal parenchymal damage on the renal function. Long-term consequences of this situation are undefined with possibility of hiperfiltration injury and further deterioration of renal function.

### Conclusions

In evaluation of children with urinary tract infection Tc 99m DMSA scyntigraphy provides not only morphological but also, valuable functional information about kidneys. The values of functional indices which we obtained in a control group are comparable with those refereed in the literature. There is a significant association between mean individual functional renal indices and the presence of morphologic abnormalities on DMSA scan (as indicator of renal parenchymal damage). Consequently, the absolute percent of renal uptake of DMSA could be use, as valuable indicator of individual renal function, in diagnosis and follow-up of children with renal parenchymal damage ( with or without VUR).

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