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Conventional and parametric kidney scintigrams — reproducibility of semiquantitative image evaluation

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Abstract

BACKGROUND: Parametric kidney scintigraphy gives the possibility of regional function distribution assessment of these organs; the clinical application of the method has thus far been limited. The usefulness of the method for the assessment of post-inflammatory scars and diabetic nephropathy has been demonstrated. Preliminary data also indicate that this type of imaging allows the assessment of kidney function after extracorporeal shock wave lithotripsy.

The aim of this study was the evaluation of the reproducibility of semiquantitative parametric kidney image evaluation.

MATERIAL AND METHODS: The results of 98 dynamic kidney scintigraphic series were evaluated, obtained from examination of 44 patients (20 males, 24 females) with nephrolithiasis, who had been treated by means of lithotripsy. The semiquantitative assessment involved conventional renoscintigraphic images obtained from summation of scintigraphic serial records in the secretory phase, and parametric clearance images. A 5-level score was applied for assessment of both types of images, based upon numbers of detected defects of the regional function (0 — no defects; 1, 2, 3 — for 1, 2 or 3 defects, and 4 for higher numbers). Altogether, 196 kidney images were evaluated. The assessment was performed independently by 2 observers: A — an experienced specialist in nuclear medicine, who evaluated the images twice, and B — a resident physician with limited experience in the field.

RESULTS: The agreement between the two evaluations by the specialist (intra-observer test) reached a level of 96% for conventional images and 90% for the parametric ones.

In the inter-observer test, full agreement reached the levels of 84% and 71% for conventional and parametric images, respectively. If ± 1 degree of the image score was taken as factual agreement, the intra-observer concordance reached 100%, and for inter-observer comparison, the agreement reached 99% and 97% for conventional and parametric images, respectively.

CONCLUSIONS: The concordance of image assessment for conventional and parametric images is very good. In observations by two physicians, a somewhat closer agreement was reached for conventional than for parametric images; the difference between the two series of image assessments was small.

Key words: parametric clearance kidney image, conventional kidney image, inter- and intra-observer concordance

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Introduction

Parametric clearance kidney images reflect organ distribution of a physiological quality which is proportional to the clearance. Such images are obtained by mathematic processing of primary conventional image series from dynamic scintigraphy of the urinary system after i.v. administration of an appropriate radiopharmaceutical (RPh). The method was developed in the 1990s by Surma and Anderson [1]. So far, the parametric kidney images were used for the evaluation of regional disturbances of kidney parenchyma resulting from urinary infections and for the assessment of kidney performance in diabetics [2, 3]. Preliminary studies were also made for the assessment of kidney function impairment in patients with urolithiasis treated by means of lithotripsy [4]. Qualitative evaluation of conventional and parametric kidney images is still subjective and depends to a substantial degree on the personal ability and experience of the observer. Moreover, the parametric images represent the processed data depicting the region-

al kidney function and differ from conventional distribution images of RPh in the kidney parenchyma as obtained from summation of conventional dynamic series.

To obtain some insight into the credibility of the imaging procedure and its assessment (and interpretation), a degree of concordance of the results obtained by the same observer in consecutive evaluations, as well as by several observers of the same data, is of paramount importance (intra- and inter-observer variability).

The aim of the present study was the assessment of the reproducibility of visual evaluation of parametric kidney clearance images as well as of conventional summation images from dynamic scintigraphy of the urinary system. In the present study, the patients with different degrees of kidney function impairment were those who underwent treatment by lithotripsy in cases of urolithiasis.

Material and methods

The results of 98 dynamic kidney studies, performed in 44 patients (20 males, 24 females) in the age range 16–70 years with urolithiasis and treated by extracorporeal lithotripsy, were used in the present study. The renoscintigraphy was made prior to extracorporeal shock wave lithotripsy (ESWL), and at 1 week and 1 month after the treatment.

The dynamic study of the urinary system (renoscintigraphy) in all the patients was made after *i.v.* administration of ^{99m}Tc-ethylenedicysteine (EC) with activity of 130 MBq. The images were collected for 20 minutes following injection; each image was accumulated over 10 seconds duration in the 64 × 64 matrix. The processing of the collected data led to a conventional summation kidney image (4–5 scintigrams in the secretory phase of ^{99m}Tc-EC in the interval from 20 to 120s after injection). From the same series, parametric clearance images were generated according to the me-thod of Surma and Anderson [1].

Analysis of the images was performed, counting the defects of the regional function of kidney parenchyma, and attributing a 5-grade score, as follows:

0 — no defects;

1, 2, 3 — one, two and three visible defects, respectively;

4 — more than 3 defects.

A total of 196 kidney images were classified.

The evaluation was made independently by two observers who had no access to the data regarding the clinical characteristics of the patients or any other information that could be derived from the renoscintigraphic investigation. The two observers were:

A. an experienced specialist in nuclear medicine, who evaluated the images twice;
B. a physician resident, with limited experience in nuclear medicine.

The conventional and parametric images were screened in a random fashion, and the interval between exercises on conventional and parametric images was no shorter than 2 months.

The concordance of evaluations (intra- and inter-observer) was assessed by using the simple proportion of concordant scores (in percent) and by Cohen's kappa coefficient of concordance (κ), which is corrected for incidental concordance [5]. The accuracy of the Kappa index estimate was expressed by standard error (SE).

The statistical significance of the difference between calculated proportions was assessed by means of the test of independence — χ^2; $p < 0.05$ was considered as statistically different.

Results

Figure 1 presents examples of parametric kidney images in patients after lithotripsy.

While evaluating the images of 196 kidneys, the more frequent defects were noted in parametric images: 139 cases (71%) *vs.* 58 (30%) in conventional summation images ($p < 0.001$). The observed deviations from the normal were more frequent in left kidneys: in parametric mode 72% *vs.* 67% in the right organ ($p = 0.43$), in conventional images a similar difference was seen: 39% *vs.* 20% ($p = 0.049$).

Results of the analysis of concordance of evaluations are presented in Tables 1 and 2.

In summary, there were higher percentages of concordant results for conventional than for parametric images; the difference was statistically significant for right kidneys in the inter-observer comparison, and for both kidneys when intra- and inter-observer comparisons are considered.

There were also higher percentages of concordant results (%, κ) for right kidneys than for left ones, and this applies both to conventional and parametric assays; however, the differences are not statistically significant.

If the differences between assessments of less than ± 1 score point are disregarded and the results treated as concordant, the concordance reached for one observer is 100%, both for the conventional and parametric images. The inter-observer concordance was also very high, reaching 99 and 97 percent for conventional and parametric images, respectively.

Discussion

When compared with conventional renoscintigraphic images, the parametric clearance images do not display extrarenal 'background' and do not visualize neighbouring or overlying organs (liver, spleen). Consequently, the deviations from the normal regional function of renal parenchyma become more easily apparent. It appears, however, that evaluation of parametric clearance images may sometimes lead to over-interpretation of the observed spatial variation of the clearance function.

The concordance of several observations of the same image increases the credibility of the method applied; however, good agreement between consecutive observations made by the same observer may contain an element of subjective judgment. If concordance between different observers is good, this obviously strengthens the credibility of the method.

As presented above, there was very good intra-observer concordance of observations (95%, $\kappa = 0.88$) for conventional images and almost the same for parametric images (90%, $\kappa = 0.85$). The inter-observer agreement was somewhat less satisfactory, i.e. 84% ($\kappa = 0.60$) for conventional and 71% ($\kappa = 0.56$) for parametric images. However, the level of difference between the observers is important. If the small differences in evaluation (*e.g.* ± 1. point of the score) are disregarded, the agreement for intra-observer evaluation reaches 100% for both types of images and is also very

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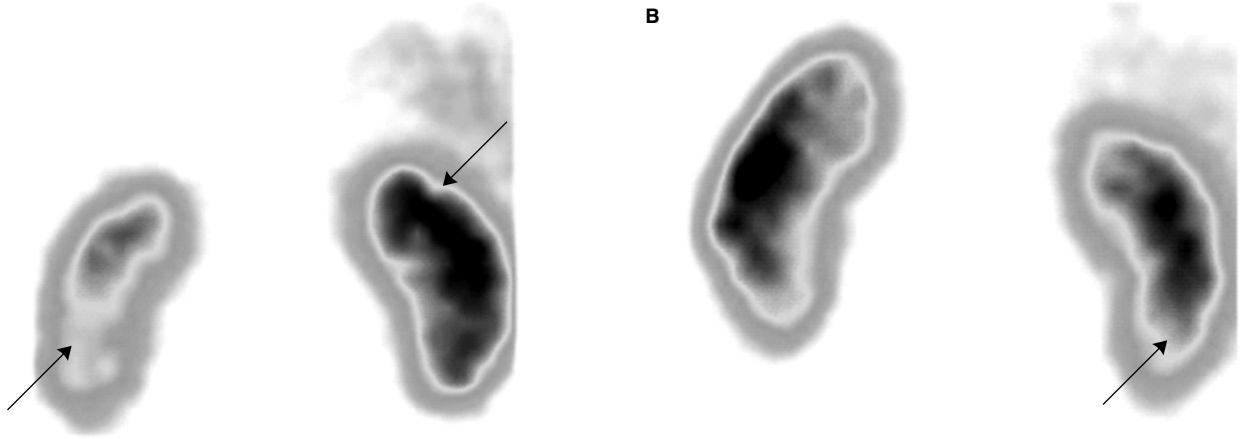

Figure 1. Parametric kidney images in two patients after lithotripsy. **A.** A prominent defect of regional clearance function in the inferior part of the left kidney. A small defect is also visible in the upper part of the right kidney. **B.** A small (uncertain) defect in the lower part of the left kidney.

Table 1. Intra-observer concordance of two evaluations of one observer. The percentages of fully concordant results (m%) are given with probabilities of differences being significant (p values) in χ^2 test. Values of the Kappa coefficient ($\kappa \pm$ SE) for left and right kidneys, and for all kidneys, for the conventional and parametric mode are presented

	Intra-observer test				
	C		P		C vs P
	Percentage (%)	$\kappa \pm$ SE	%	$\kappa \pm$ SE	(p)
LK	95	0.88 ± 0.05	90	0.85 ± 0.05	0.08
RK	97	0.89 ± 0.06	91	0.86 ± 0.05	0.07
BK	96	0.88 ± 0.04	90.5	0.85 ± 0.03	0.012
LK *vs.* RK	p = 0.47		p = 0.49		

C — conventional image; P — parametric image; SE — standard error; LK — left kidney; RK — right kidney; BK — both kidneys

Table 2.Inter-observer concordance of evaluations — in percent of fully concordant assays, together with probabilities of differences being significant (p values) in the χ^2 test. Values of the Kappa coefficient ($\kappa \pm$ SE) are presented separately for the left and right kidneys, and for all kidneys

	Intra-observer test				
	C		P		C vs P
	Percentage (%)	$\kappa \pm$ SE	%	$\kappa \pm$ SE	(p)
LK	80	0.57 ± 0.08	68	0.52 ± 0.07	0.07
RK	89	0.63 ± 0.09	75	0.60 ± 0.07	0.01
BK	84	0.60 ± 0.06	71	0.56 ± 0.05	0.002
LK *vs.* RK	p = 0.08		p = 0.34		

C — conventional image; P — parametric image; SE — standard error; LK — left kidney; RK — right kidney; BK — both kidneys

high for the inter-observer comparison (99 and 97% for conventional and parametric images, respectively). Therefore, the visual interpretation of both kinds of images may be accepted as highly satisfactory for clinical purposes. This seems true in spite of the fact that changes in parametric images were seen more frequently than in their conventional counterparts. This seems to support the hypothesis that clearance parametric evaluation of kidneys is more sensitive than that based on conventional summation of several images derived from simple dynamic renoscintigraphy. This difference was seen quite clearly in our previous study on diabetics [3].

The patients who were subjected to the evaluation of kidney defects in this study were those subjected to extracorporeal lithotripsy. This cohort displayed quite a range of defect frequency in the renal images, and such circumstances seem to provide more convenient background for the evaluation of both methods [5–7].

A less satisfactory concordance of results was obtained for the left kidney than for the right counterpart. This may be of methodological origin — statistically the difference was significant only for the conventional summation images. However, there could be some anatomical difference between the left and right kidneys.

In summary, parametric clearance kidney imaging is a procedure with satisfactory reproducibility. It seems, nevertheless, that a comparative study in the same subjects, using both the parametric clearance imaging and static scintigraphy with ^{99m}Tc-DMSA, is still highly advisable [8, 9].

Conclusions

Inter- and intra-observer concordance of kidney parenchyma imaging by conventional summation of renoscintigraphic scanning and clearance parametric images is satisfactory. The differences in scores (in most cases) did not exceed one point on a five-point scale.

In both (intra- and inter-observer) concordance studies, a better agreement was obtained for conventional than for parametric images. This observation may be explained by the fact that the number of details seen in parametric images is higher than that in conventional summation images, which probably makes interpretation more difficult.

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