



Evaluation of Renal Function in Children by Tc-99m DTPA Scintigraphy

Çocuklarda Böbrek Fonksiyonunun Tc-99m DTPA Sintigrafisi ile Değerlendirilmesi

Tc-99m DTPA Renal Scintigraphy in Child

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Özet

Amaç: Dinamik böbrek sintigrafisi hem yapısal hem de fonksiyonel böbrek patolojilerini gösterebilir. Teknesyum-99m (Tc-99m) dietilen triamin pentaasetik asit (DTPA) ile yapılan dinamik böbrek sintigrafisi ile çocuklarda böbrek fonksiyonlarını değerlendirmeyi ve sintigrafik olarak saptanabilen atrofik böbrek sıklığını bulmayı amaçladık. **Gereç ve Yöntem:** Bu retrospektif çalışmaya üriner sistem yakınmaları olan ve yaş ortalaması 6.15 ± 4.41 yıl olarak bulunan 17 çocuğun (12 erkek, 5 kız) dinamik böbrek sintigrafileri dahil edildi. Çocukların yaş ortalamaları 6.15 ± 4.41 yıl idi. Görüntüler, intravenöz (İV) yolla Tc-99m DTPA enjeksiyonu sonrası çift başlı gama kamera ile elde edildi. **Bulgular:** Otuz dört böbreğin fonksiyonu değerlendirildi. Olguların %35.3'ünde (n=6/17) sol böbrekte ve %11.8'inde (n=2/17) sağ böbrekte azalmış perfüzyon saptandı. Olguların %52.9'unda (n=9/17) sol böbrekte ve %29.4'ünde (n=5/17) sağ böbrekte T_{max} değerinde uzama gösterildi. Olguların %64.7'sinde (n=11/17) sol böbrekte ve %88.2'sinde (n=15/17) sağ böbrekte glomerüler filtrasyon hızı normal sınırlarda idi. Olguların %29.4'ünde (n=5/17) sol böbrekte ve %11.8'inde (n=2/17) sağ böbrekte gecikmiş ekskresyon saptandı. Olguların %58.8'inde (n=10/17) sol böbrekte ve %70.6'sında (n=12/17) sağ böbrekte İV diüretige yanıt veren radyoaktivite stazı gösterildi. Olguların %17.6'sında (n=3/17) sol böbrekte ve %5.9'unda (n=1/17) sağ böbrekte atrofi lehine dinamik böbrek sintigrafisi bulguları elde edildi. **Tartışma:** Tc-99m DTPA dinamik böbrek sintigrafisi çocuklarda böbrek fonksiyonlarını değerlendirmede ve atrofik böbrek sıklığını belirlemede yararlı bulunmuştur.

Anahtar Kelimeler

Radyonüklit Görüntüleme; Teknesyum Tc 99m Pentetat; Çocuk; Böbrek

Abstract

Aim: Dynamic renal scintigraphy can demonstrate both structural and functional renal pathologies. Our aim was to evaluate renal functions in children by technetium-99m diethylenetriaminepentaacetic acid (Tc-99m DTPA) dynamic renal scintigraphy, and to determine the frequency of scintigraphically detectable atrophic kidneys. **Material and Method:** Dynamic renal scintigraphy studies of seventeen children (12 males, five females) with urinary system complaints, having a mean age of 6.15 ± 4.41 years, were included in this retrospective study. Images were obtained with a dual-head gamma camera after intravenous (IV) injection of Tc-99m DTPA. **Results:** The functions of 34 kidneys were evaluated. Decreased perfusion of the left and right kidneys was detected in 35.3% (n=6/17) and 11.8% (n=2/17) of cases, respectively. Prolongation in T_{max} of the left and right kidneys was shown in 52.9% (n=9/17) and 29.4% (n=5/17) of the cases, respectively. Glomerular filtration rate of the left and right kidneys was normal in 64.7% (n=11/17) and 88.2% (n=15/17) of cases, respectively. Delayed excretion of the left and right kidneys was detected in 29.4% (n=5/17) and 11.8% (n=2/17) of cases, respectively. Stasis of urine in the left and right kidneys which responded to IV diuretics was demonstrated in 58.8% (n=10/17) and 70.6% (n=12/17) of cases, respectively. Dynamic renal scintigraphy findings in favour of left and right renal atrophy were obtained in 17.6% (n=3/17) and 5.9% (n=1/17) of cases, respectively. **Discussion:** Dynamic renal scintigraphy with Tc-99m DTPA was found to be useful in the evaluation of renal functions of children and in determining the frequency of atrophic kidneys.

Keywords

Radionuclide Imaging; Technetium Tc 99m Pentetate; Child; Kidney

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Introduction

One of the main clinical applications of renal scintigraphy is quantitative evaluation of renal functions in urinary tract diseases of children. Pediatric radionuclide imaging such as technetium-99m diethylenetriaminepentaacetic acid (Tc-99m DTPA) scintigraphy entails a relatively low radiation burden [1, 2] with limited need for sedation [2]. Today, Tc-99m DTPA seems to be the most commonly used radiopharmaceutical for renal scintigraphy [3]. Tc-99m DTPA is used for the evaluation of glomerular filtration rate (GFR) because it is primarily filtered by glomeruli without undergoing tubular secretion or re-absorption [1]. With regard to evaluation of perfusion and parenchymal function parameters, the performance of Tc-99m DTPA was found to be better than other agents such as Tc-99m mercaptoacetyl-triglycine (MAG3) in patients with renal allograft dysfunction [4]. Dynamic renal scintigraphy can demonstrate both structural and functional renal pathologies [5] and can support the diagnosis of ureteropelvic junction obstruction in vesicoureteral reflux [6]. There is not any contraindication for renal scintigraphy in pediatric patients, but it may not be possible to evaluate the differential renal function (DRF) and/or drainage properly if the renal functions are impaired [7]. In this retrospective study we aimed to evaluate renal functions in children by Tc-99m DTPA dynamic renal scintigraphy, and to determine the frequency of scintigraphically detectable atrophic kidneys.

Materials and Method

Patient population

Between January 2011 and November 2011, the dynamic renal scintigraphy studies of 49 patients were evaluated. 17 children (12 males, five females) with urinary tract complaints were included in this retrospective study; all the adult patients (n=32) were excluded. The mean age of the children was 6.15 ± 4.41 years. All the procedures were performed according to the World Medical Association Declaration of Helsinki (revised in 2000, Edinburgh). All the patients' parents were informed about scintigraphic imaging procedures, and informed consent was obtained from them.

Scintigraphic imaging protocol and image interpretation

In order for the patients to be well hydrated, they were asked to drink water approximately 30–60 minutes before the study. Babies were breastfed or bottlefed. The scintigraphic images were obtained with a dual-head gamma camera (Siemens, eCAM, Germany) with a low energy all purpose collimator following the intravenous (IV) bolus injection of Tc-99m DTPA at an average dose of 0.1 mCi (3.7 MBq)/kg body weight. Acquisition of the scintigraphic images was done in the posterior projection, gamma camera viewing the area of the kidneys and bladders with the patient in the supine position. The images were recorded within the $140 \text{ keV} \pm 20\%$ energy range, using a 64×64 matrix and at least 1.50 zoom factor. 60 images (1 sec/frame) were taken for the perfusion phase and 40 images (30 sec/frame) were taken for the parenchymal phase. Kidney perfusion was evaluated visually and also by the perfusion time-activity curves. Functional parameters were derived from the renogram curves which were obtained from regions of interests (ROI) over the right and left kidney and from the background

ROI, inferolateral to the kidneys. GFR of the left and right kidneys was calculated by Gates' method without blood or urine sampling [1]. Detection of a small kidney on scintigraphy with poor renal function, defined as a DFR less than 10% [8], accompanied by decreased dimensions and cortical thickness on ultrasonography (US), were accepted as criteria for renal atrophy. Scintigraphic images were evaluated by a board-certified nuclear medicine specialist with 10 years of experience.

Data analysis

The mean age of the patients was calculated. The percentages and the numbers of right and left kidneys with normal and decreased perfusion, with normal and prolonged time-to-peak activity (T_{max}), with normal and delayed excretion, and with stasis of urine that responded to IV diuretics were obtained. The percentages and the numbers of right and left kidneys with findings indicating atrophy were also determined. All analyses were performed using SPSS software (version 16.0; SPSS Inc; Chicago, IL, USA).

Results

In total, the functions of 34 kidneys were evaluated. The perfusion of the left and right kidneys were normal in 64.7% (n=11/17) and 88.2% (n=15/17) of cases, respectively. Decreased perfusion of the left and right kidneys were detected in 35.3% (n=6/17) and 11.8% (n=2/17) of cases, respectively. T_{max} of the left and right kidneys were normal in 47% (n=8/17) and 70.6% (n=12/17) of cases, respectively. Prolongation in T_{max} of the left and right kidneys were detected in 52.9% (n=9/17) and 29.4% (n=5/17) of cases, respectively. In 17.6% (n=3/17) of the left kidneys and in 29.4% (n=5/17) of the right kidneys with normal perfusions, prolongation in T_{max} was demonstrated. Two of these left kidneys demonstrated hydronephrotic changes whereas the other left kidney and four right kidneys had normal uptake, and showed normal relative renal function. In the fifth right kidney with normal perfusion and prolonged T_{max} uptake was normal in the upper and middle pole, and was reduced in the lower pole. GFR of the left and right kidneys was normal in 64.7% (n=11/17) and 88.2% (n=15/17) of cases, respectively. Mean GFR of the left and right kidneys was 47.87 ± 29.48 mL/min and 56.77 ± 28.62 mL/min, respectively. Excretion of the left and right kidneys was normal in 11.8% (n=2/17) and 17.6% (n=3/17) of cases, respectively, in which the renal collecting systems and urinary bladder were visualized without delay. Delayed excretion of the left kidney and right kidneys (Fig. 1) were detected in 29.4% (n=5/17) and 11.8% (n=2/17) of cases, respectively. Stasis of urine in the left and right kidneys that responded to IV diuretics were demonstrated in 58.8% (n=10/17) and 70.6% (n=12/17) of cases, respectively. Dynamic renal scintigraphy findings in favour of left and right renal atrophy were obtained in 17.6% (n=3/17) and 5.9% (n=1/17) of cases, respectively.

Discussion

The use of nuclear medicine methods in pediatric patients has been in rapid and continuous development for a long time [9]. In pediatric nephrology practice, radionuclide imaging allows quantification of renal functions which cannot be done by con-

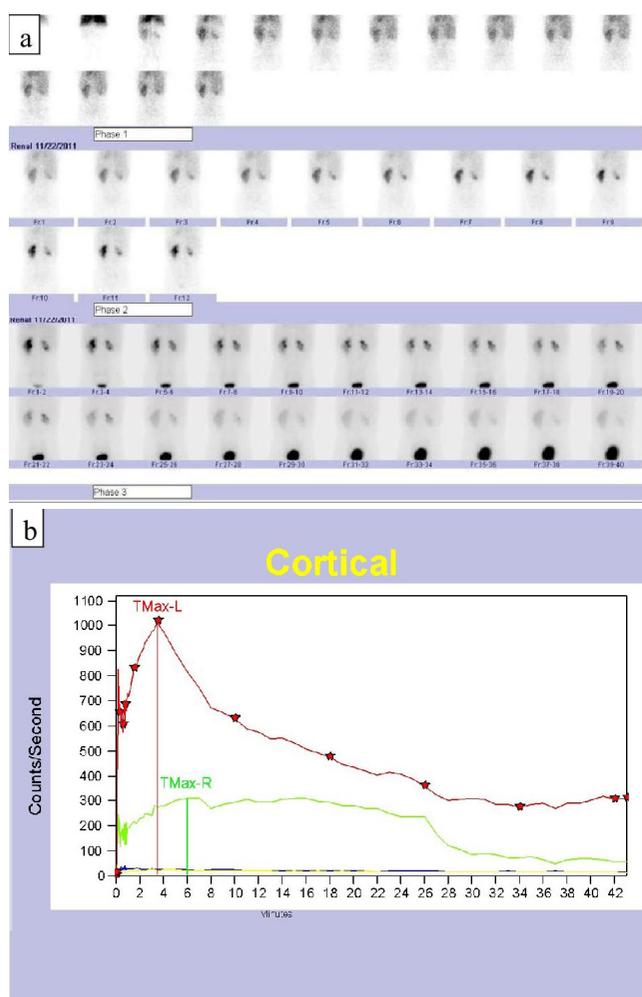


Figure 1. A normal functioning left kidney and a right kidney with hydronephrotic changes were demonstrated with Tc-99m DTPA dynamic renal scintigraphy in an eight-year-old girl (a), including the renogram curve (b).

ventional diagnostic modalities such as ultrasonography (US) or excretory urography [2]. Dynamic renal scintigraphy reveals morphologic and functional abnormalities in the affected kidneys by giving a relatively low radiation dose. In dynamic renal scintigraphy with Tc-99m-DTPA, there is no need for sampling of urine or blood to calculate the GFR [1]. Tc-99m DTPA is preferred not only for the evaluation of perfusion and glomerular filtration, but also for the assessment of obstructive uropathy and vesicoureteral reflux [10]. Unilateral hydronephrosis due to unilateral ureteropelvic junction obstruction is a common indication for renal scintigraphy in children and Tc-99m DTPA is a specific scintigraphic agent well-known for its value in evaluation of renal functions, including not only those with unilateral ureteropelvic junction obstruction [11], but also those of renal allografts [12]. In a child with chronic ureteral stones, Tc-99m DTPA scintigraphy revealed severe loss of function after stone removal and indicated the need for nephrectomy [13]. Tc-99m DTPA has also been used in the diagnosis of developmental anomalies such as horseshoe kidney [14] and fused pelvic kidneys [15]. Çelik et al. [16] compared the relative renal function measurements in children with Tc-99m DTPA and Tc-99m dimercaptosuccinic acid (DMSA), and found Tc-99m to be a reliable and alternative agent that abolishes the need for an additional Tc-99m DMSA scan. Early phase Tc-99m DTPA renal scintigraphy can give information about individual kidney func-

tions [9]. In our study, Tc-99m DTPA scintigraphy gave us the necessary information about separate right and left renal functions in pediatric patients, therefore having a major influence in treatment planning and follow-up. In small infants, accurate evaluation of DRF may not be possible with Tc-99m DTPA [7]. In our study group, since the mean age of our patients was 6.15 ± 4.41 years, we could estimate DRF accurately with Tc-99m DTPA.

Scintigraphic studies allow the physician to differentiate obstructive and non-obstructive etiologies and to provide assessment of renal functions of the hydronephrotic kidney, which help to make the choice between conservative or surgical approaches [5]. In a study including infants with hydronephrosis, Tc-99m DTPA scintigraphy was able to demonstrate a poorly functioning kidney with a DRF less than 10% [8]. Urologists generally accept that there is a poor chance of renal function recovery after de-obstruction if relative renographic GFR is less than 10% [17]. In our study, detection of atrophy in four kidneys which were small in size and had DRF less than 10% played a significant role in decision making for a surgical approach to these children with atrophic kidneys.

Our study has limitations because of its retrospective design. Firstly, we could not compare renal scintigraphy findings of all our patients with renal radiologic findings in order to assess the exact sensitivity and specificity of Tc-99m DTPA scans in detecting all types of morphological changes. Secondly, we could not compare the results of Tc-99m DTPA scans with the scans obtained with other scintigraphic agents such as Tc-99m DMSA or Tc-99m MAG3. Thirdly, we could not compare the findings obtained with Tc-99m DTPA in different patient groups because of the limited number of patients. However, the number of children in our study was sufficient to show the usefulness of Tc-99m DTPA in evaluating renal perfusion, T_{max} , excretion, stasis of urine, and also in detecting renal atrophy.

In conclusion, dynamic renal scintigraphy with Tc-99m DTPA maintains its indispensable place in evaluation of renal functions in pediatric renal pathologies, guiding surgeons and pediatricians in making decisions. We found that Tc-99m DTPA renal scintigraphy was useful in the evaluation of renal functions of children and in obtaining the frequency of scintigraphically detectable atrophic kidneys. Further studies including correlations with other imaging tools such as US and/or magnetic resonance imaging will help us to better understand the role of Tc-99m DTPA scans in assessing various kidney diseases of children.

Competing interests

The authors declare that they have no competing interests.

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