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# DIURETIC RENOGRAPHY IN CHILDREN: A NON-INVASIVE METHOD FOR THE ASSESSMENT OF UPPER URINARY TRACT PATHOLOGIES*

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**SUMMARY: Durak H, Bernay İ, Erbengi G, Ulutuncel N. (Department of Nuclear Medicine, Hacettepe University Faculty of Medicine, Ankara, Turkey). Diuretic renography in children: a non-invasive method for the assessment of upper urinary tract pathologies. Turk J Pediatr 33: 235-243, 1991.**

**Thirty-eight kidneys from 20 children were studied with diuretic renography and the findings in 32 kidneys were compared with the results obtained using IVP. The diuretic renography findings were consistent with those of the IVP in 72 percent of the patients. The main disparity was the dilated nonobstructed pattern observed in the kidneys with normal IVP's, which is pointed out as being an asset of diuretic renography in revealing the functional status of kidneys.**

**The sensitivity in detecting true obstruction was found to be 67 percent (4/6), and the specificity 95 percent (20/21). The accuracy of the technique was 85 percent with a false (+) rate of 5 percent (1/21) and false (−) rate of 33 percent (2/6).**

**Diuretic renography is a simple, safe, non-invasive technique, easily applied to children with high specificity in excluding obstruction in a dilated renal pelvis.** *Key words: radioisotope renography, radionuclide imaging.*

Retention of either tracer or contrast material within a renal pelvis is a common finding in the practice of pediatric radiology and nuclear medicine[1]. The diagnosis of obstruction as the cause of this type of retention is important because surgical intervention in obstructive hydronephrosis will spare renal function, whereas, a nonobstructed dilated collecting system does not require surgery[2].

Diuretic renography was first described by O'Reilly et al[3] in 1978, and subsequent reports confirmed its value as a useful technique in the assessment of dilated upper urinary tract to distinguish between true obstruction and nonobstructive dilatation[2,4-9]. Diuretic renography is a simple, safe, non-invasive technique, easily applied to children.

In the present study, diuretic renography was applied to 20 children with various urinary symptoms and the results were compared with intravenous pyelography (IVP).

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## Material and Methods

In this study thirty-eight kidneys from 20 children were investigated. Renograms were performed with $^{99m}$Tc DTPA using an intravenous (i.v.) dose of 6 m Ci/1.7m$^2$. The patients were observed from the posterior view in the supine position with a Toshiba GCL-501 gamma camera and associated computer. All children were normally hydrated. Furosemide in a dose of 0.5 mg/kg was administered intravenously approximately 20 minutes after the radiopharmaceutical was injected. Observation resumed about 20 minutes after administration of the diuretic.

After data collection was complete, each kidney was analyzed by the computer. The kidney regions of interest including the pelvis and a background area adjacent to each kidney were drawn and background corrected time-activity curves were generated for each kidney. Split renal function estimates were derived from the one minute interval between the 80$^{th}$ and the 140$^{th}$ second of the curve. The shape of the time activity curve and the pattern of response to the diuretic were evaluated as described by O'Reilly et al[3] as:

*Group I response* : Normal renogram (Fig. 1).

*Group II response* : No excretion even after furosemide (obstructive pattern) (Fig. 2).

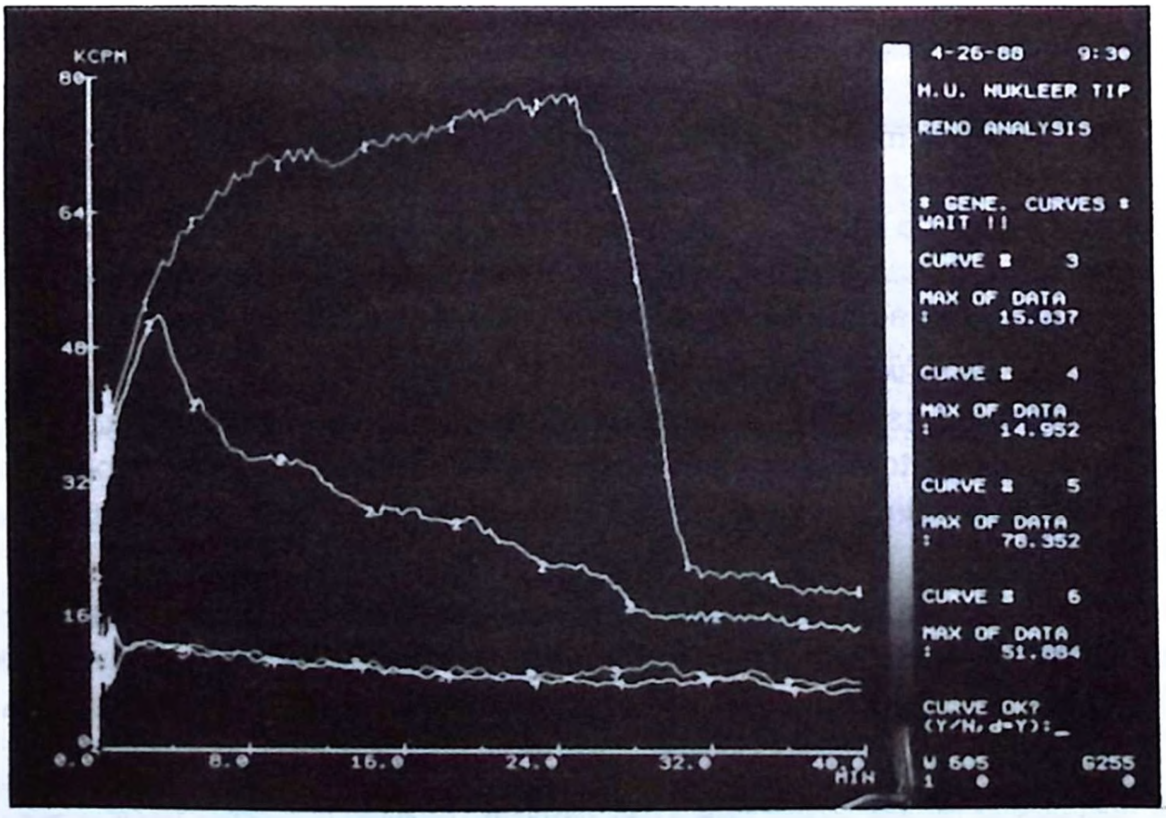


Fig. 1: Curve 2 is a normal renogram curve (Group I). Curve I reveals the dilated nonobstructive pattern of response with a rapid excretion after the diuretic administered at 20 min (Group IIIa).

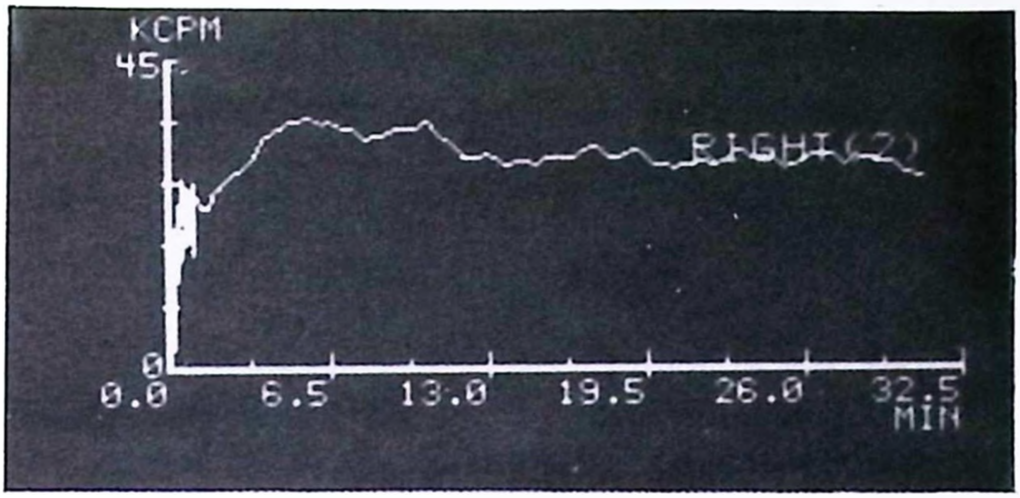


Fig. 2: Obstructive curve pattern with no response to the diuretic administered at 20 min (Group II).

*Group III response* : *IIIa* : Rapid excretion after furosemide (dilated nonobstructive pattern) (Fig. 1).

*IIIb* : Partial improvement after furosemide (equivocal) (Fig. 3).

Group IIIb which was accepted as a dilated nonobstructive pattern is discussed. Impairment of renal function is accepted as being less than 40 percent of relative function[9].

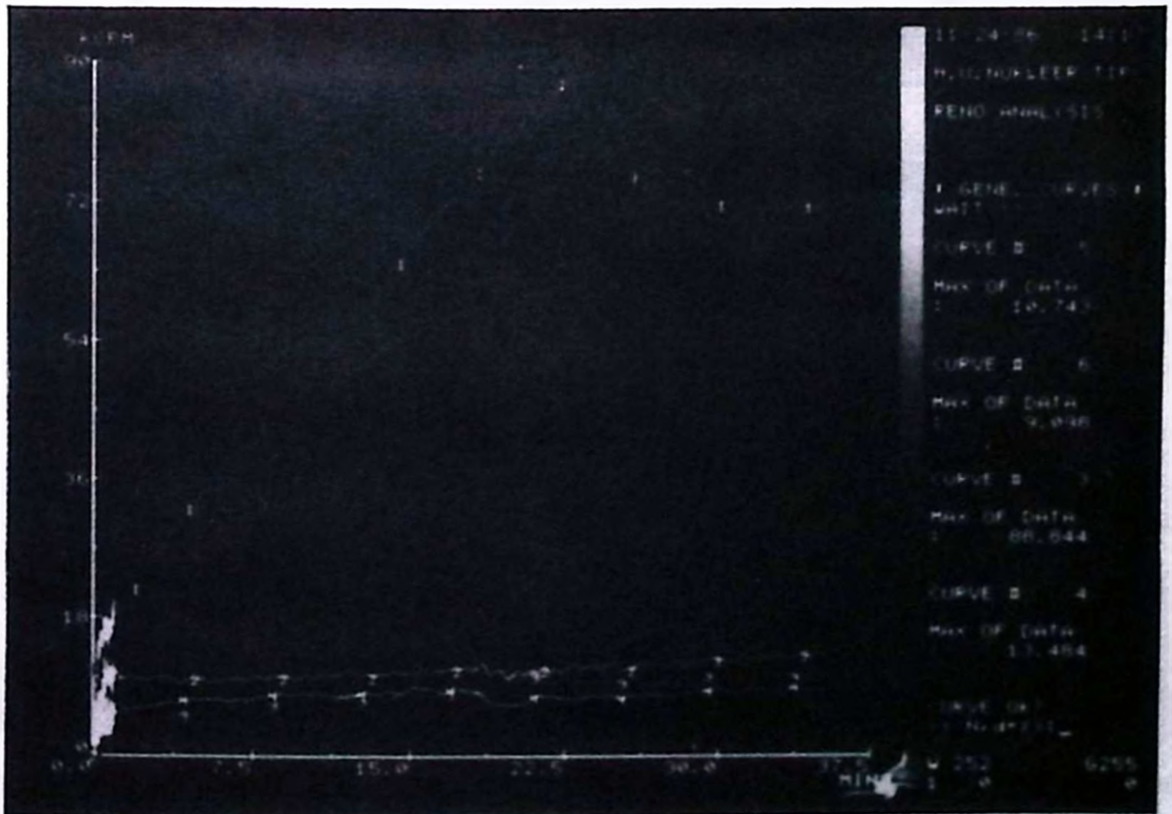

Fig. 3: Curve 1 reveals the IIIb response with partial improvement after the diuretic administered at 20 min.

## Results

Diuretic renography was performed on 20 children with various urinary tract symptoms regardless of the presence of any suspected obstructions. Clinical diagnoses of the patients are summarized in Table I. Of the 38 individual kidneys examined, 32 kidneys had comparable IVP's. Ultrasonography was performed in ten patients but the results were not compared with those obtained from diuretic renography because of the small number of patients studied. There were eleven girls and nine boys, ranging in age from 4.5 months to 12 years (average five years) with six patients $\leqslant$ one year of age and 12 patients $\leqslant$ five years of age.

*Diuretic Renography Results :* Ten kidneys were in Group I, seven kidneys in Group II, nine kidneys in Group IIIa, and five kidneys in Group IIIb. Seven kidneys were evaluated as nonfunctioning according to split renal function estimates (Table II).

TABLE I: Clinical Diagnoses of the Patients

| Clinical Diagnoses | Number of Patients |
|---|---|
| Hydronephrosis | 7 |
| Genitourinary system abnormality | 5 |
| Pelvic dilatation after pyeloplasty | 3 |
| Malignancy | 2 |
| VUR with atrophy | 2 |
| Hemolytic uremic syndrome | 1 |
| **Total** | **20** |

TABLE II: Number of Kidneys in Groups I, II, IIIa, IIIb and Non-functioning Kidneys Demonstrated by Diuretic Renography

| Group | Number of Patients |
|---|---|
| I | 10 |
| II | 7 |
| IIIa | 9 |
| IIIb | 5 |
| Non-functioning | 7 |
| **Total** | **38** |

Scan findings of a kidney with an obstructive response (Group II) are shown in Fig. 4, while scan findings of a kidney with a non-obstructive dilated pattern of response (Group IIIa) are illustrated in Fig. 5.

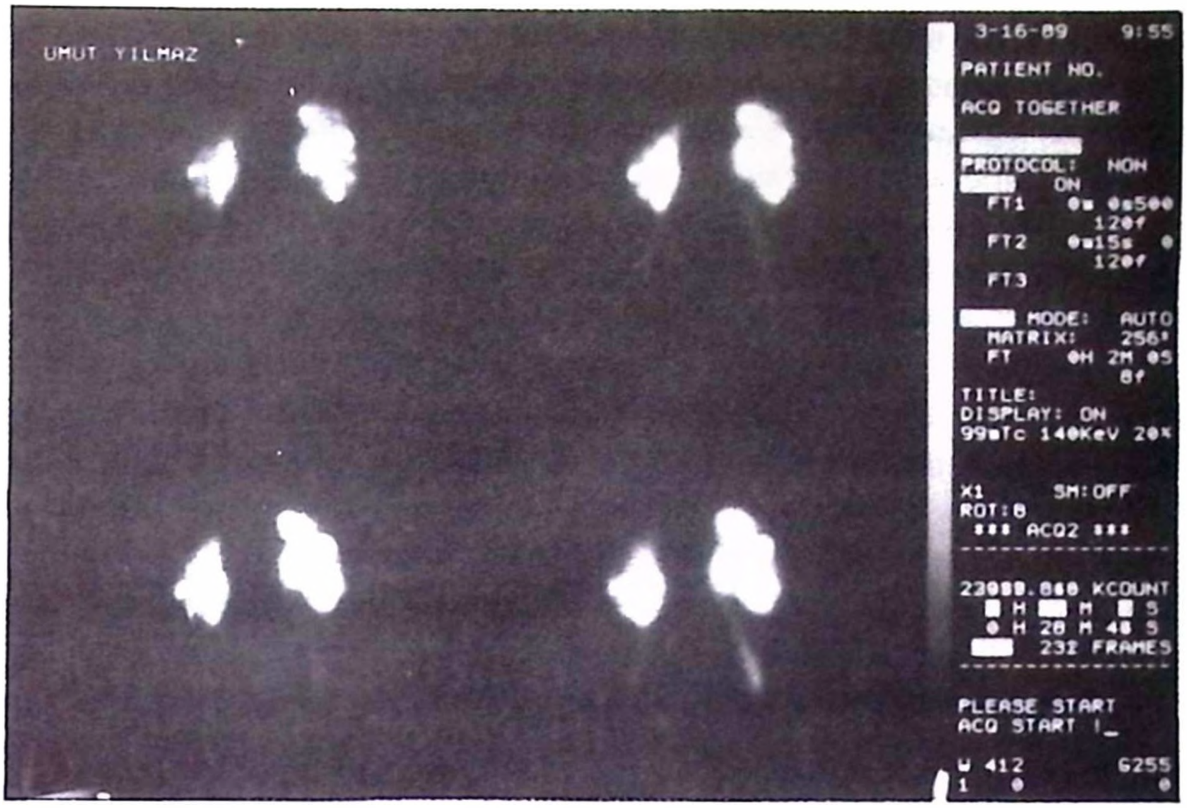


Fig. 4: Scan findings of an obstructive kidney. Upper left: 15 min., upper right: 20 min., lower left: 25 min. and lower right 30 min. image after the administration of radiopharmaceutical. Diuretic was given at 20 min. There is no washout observed from the pelvis after the administration of the diuretic.

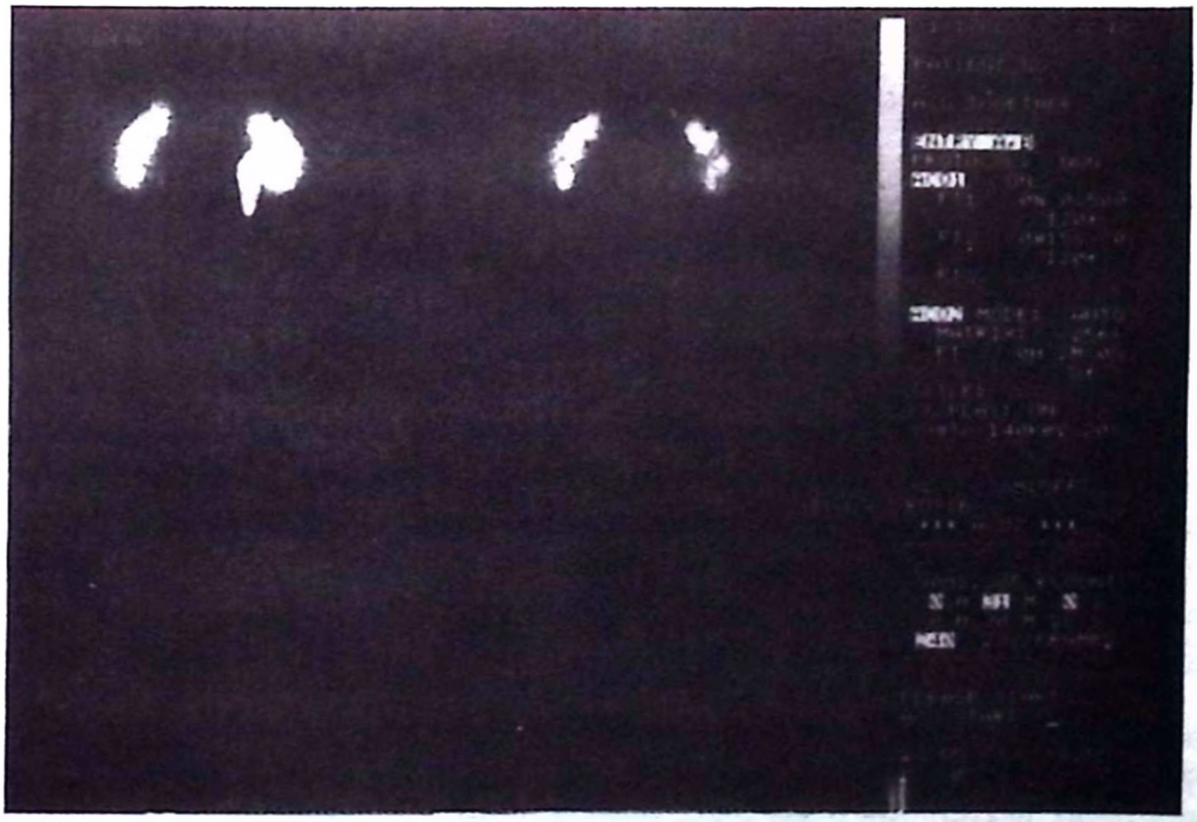

Fig. 5: Scan findings of a dilated nonobstructive kidney. Upper left: 15 min., upper right: 20 min., lower left: 25 min. and lower right 30 min. image after the administration of the radiopharmaceutical. Diuretic was given at 20 min. Washout from the pelvis is obvious after the administration of the diuretic.

The findings on the diuretic renograms were consistent with those obtained from the IVPs of 23 kidneys (72%) but differed in nine (28%). In seven kidneys, the disparity consisted of dilated nonobstructed renogram patterns observed on the normal IVPs. One kidney, which was evaluated as nonfunctioning by diuretic renography, was visualized by IVP, and seemed obstructed while one kidney, evaluated as normal by IVP, had normal excretion but a diminished renogram curve, suggesting hypofunction (Table III).

TABLE III: Diuretic Renography Findings Compared With IVP Findings of Patients

| | | Diuretic Renography | | | | |
|---|---|---|---|---|---|---|
| IVP | I | II | IIIa | IIIb | Non-function | Total |
| Normal | 7 | | 5 | 2 | | 14 |
| Hydronephrosis | | 1 | 2 | 1 | | 4 |
| Ureteral ectasia | 2 | | 1 | | | 3 |
| Obstructive (U-P) | | 3 | | | | 3 |
| No excretion | | 1 | | 1 | 1 | 3 |
| Calyceal clubbing | 1 | | | | | 1 |
| Non-functioning | | | | | 4 | 4 |
| Total | 10 | 5 | 8 | 4 | 5 | 32 |

The diagnosis of obstruction or nonobstructive dilatation was confirmed by either surgery or clinical follow-up in 27 kidneys and, therefore, only these kidneys are included in sensitivity and specificity calculations.

The sensitivity of detecting true obstruction was 67 percent (4/6), specificity 95 percent (20/21), with a false (+) rate of 5 percent (1/21) and a false (–) rate of 33 percent (2/6). Two kidneys with confirmed obstruction were not visualized by diuretic renography and were interpreted as nonfunctioning. Thus 2/6 (33%) should be considered an indeterminate rate rather than a false (–) rate. The test was 89 percent accurate (24/27).

*Group IIIb :* There were five kidneys under study in Group IIIb. In two kidneys, the contralateral kidney had a ureteropelvic (U-P) obstruction. One kidney was part of a horseshoe kidney while the other had a U-P obstruction confirmed by surgery. The other two, were the kidneys of the same patient, one of which had a prior pyelolithotomy, and the other a second pyeloplasty for U-P obstruction.

**Discussion**

A diuretic renogram has two components: the histogram and the scan. The histogram is a time activity curve which graphically reveals the accumulation and washout of the radioisotope before and after the administration of furosemide. In the case of true obstruction, the radioactive tracer fails to washout after injection of furosemide and that occurrence is mainly determined from the histogram. The scan provides serial images which reveal the anatomic localization of the obstruction or the dilatation. The dose of radiation absorbed is considerably lower than that used in the IVP. The kidney receives 20 mrad/mCi, the whole body 6 mrad/mCi and the ovaries 4 mrad/mCi. The bladder is the critical organ, receiving 490 mrad/mCi[10]. In a standard study, it was reported that the IVP delivers 1200 mrads to the ovaries and 220 mrads to the bone marrow[11].

Diuretic renography may be used in evaluating ureteropelvic (U-P) junction obstruction[5], megaureter[5,7], urinary diversion (stomal stenosis), ureteroneocystostomy, Prune Belly syndrome, ureteral valves, ureteral injury (excluding obstruction in renal transplant rejection[5]) and in persistent dilatation after surgery[2,7].

Counts from an overdistended bladder may interfere with the counts from the lower urinary tract and pelvic kidneys. Bladder pressure can also be trasmitted to the renal pelvis even without reflux[3]. In high grade vesicoureteral reflux (VUR), radioactive urine from the bladder refluxes back to the pelvis, simulating an obstruction[5].

A poorly functioning kidney also simulates an obstructive pattern by not being able to respond to the diuretic[5,7,9,12].

In severe hydronephrosis, the collecting system becomes too large, so an increase in the flow of urine may not be able to overcome the "mixing chamber effect" described as the slow turnover of the radiolabeled urine in a large volume. This may result in insufficient emptying of the renal pelvis, simulating obstruction[2,7,9].

The only false (+) interpretation in our study was a poorly functioning kidney (19% of total function) with a fourth grade VUR. Two false (−) interpretations were very poorly functioning kidneys which were not visualized by diuretic renography.

Shore et al[2] and Senac et al[7] reported the sensitivity for detecting obstruction as 83 percent and the specificity as 94 and 86 percent, respectively. According to Senac and associates, the accuracy of the test was 85 percent. We found the degree of sensitivity to be less than that reported in the literature. The reason for our result was that two kidneys in the study had not been visualized during diuretic renography, however, during surgery they were found to be obstructed.

*Disparity with IVP :* In seven kidneys with normal IVP's, five kidneys had a Group IIIa and two kidneys had a Group IIIb response to the diuretic.

Healthy kidneys share the excretion of water and solutes equally in proportion to the renal mass and function. In the case of a unilateral obstruction, water and electrolyte excretion shifts to the unaffected kidney, increasing the water flow through it[13]. Every tract has its own individual maximum flow rate potential and may fail to compensate at higher flow rates[14]. Thus, we can speculate that it may even be difficult for a normally functioning kidney to handle total water and electrolyte excretion, resulting in delayed pelvic clearance and pelvic dilatation in the long run. Diuretic injection may overcome this problem by further elevating the pressure[14]. This type of loading of a kidney may be detected by diuretic renography before any significant anatomical changes occur, which may explain the disparity with IVP.

In some cases, the lesser affected kidney may have a masked obstruction in which the pressure rise may overcome the obstruction, demonstrating a Group IIIa or IIIb response[13]. Koff et al[5] accepted both Group IIIa and Group IIIb responses as a dilated nonobstructed pattern and found that only one child with a Group IIIb response had an obstruction. According to Koff's data, Groups IIIa and IIIb are both accepted as dilated nonobstructive patterns in this study, but, as mentioned above, a masked obstruction cannot be ruled out and the patients should be followed.

There is no one set method for diagnosing obstructions[9,10]. Direct renal perfusion studies, IVP, and parenchymal mean transit times are often used. Diuretic renography is a highly sensitive non-invasive technique which does not require urinary tract instrumentation and provides information about the functional status of kidneys.

We conclude that diuretic renography is highly specific for nonobstructed kidneys, however, poorly functioning obstructed kidneys can lower the sensitivity of the technique.

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