

EVALUATION OF NEONATAL HYDRONEPHROSIS WITH DIURETIC RENOGRAPHY

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ABSTRACT

The common use of maternal ultrasonography has increased the apparent incidence of neonatal hydronephrosis. Many of these cases are found to have partial obstruction at the ureteropelvic junction (UPJ). These patients are safely managed in our institution with careful observation and only occasionally require surgical intervention. The authors present two contrasting cases of suspected UPJ obstruction in the neonatal period. The diagnostic evaluation and management in these two patients with similar presentation and markedly different outcome are discussed. The role of various imaging modalities including voiding cystourethrography (VCUG), intravenous pyelography (IVP), ultrasonography (US) and diuretic radionuclide renography was discussed.

The relationship of normalized renal uptake and diuretic clearance half-time ($T_{1/2}$) with outcome was examined in 50 patients with prenatally diagnosed hydronephrosis. The normalized uptake value is the fraction of the total Tc99m DTPA extracted by each kidney between 60 and 120 seconds following the injection of the patient. There was a statistically significant difference in the renal uptake and $T_{1/2}$ in those kidneys that subsequently required surgery compared to those which were managed conservatively. The predictive value of renal uptake and $T_{1/2}$ in identifying those patients who require surgical correction is not yet fully defined.

Key Words: Diuretic renogram, Hydronephrosis, pediatrics, UPJ obstruction

CASE SUMMARY

CASE ONE

A newborn female was referred to our institution in May, 1992 for the evaluation of bilateral hydronephrosis. This abnormality was detected prenatally during a routine obstetric ultrasound (Fig. 1). There were no signs or symptoms of other congenital disorders. A voiding cystourethrography (VCUG) was performed at 3 weeks of age. There was no evidence of vesico-ureteral reflux. A diuretic radionuclide renography performed following the VCUG demonstrated decreased perfusion and uptake in the right kidney. Urinary activity

remained in the renal pelvis at 20 minutes bilaterally. The stasis in the left kidney cleared only partially with lasix administration. The half-time of washout ($T_{1/2}$) was more than 20 minutes. The right renal stasis failed to respond to lasix with no significant clearance over 30 minutes (Fig. 2). The normalized uptake in the left and right kidney was measured as 1.2% and 0.6%, respectively. (The normalized uptake value is the fraction of the total Tc99m DTPA extracted by each kidney between 60 and 120 seconds following the injection of the patient).

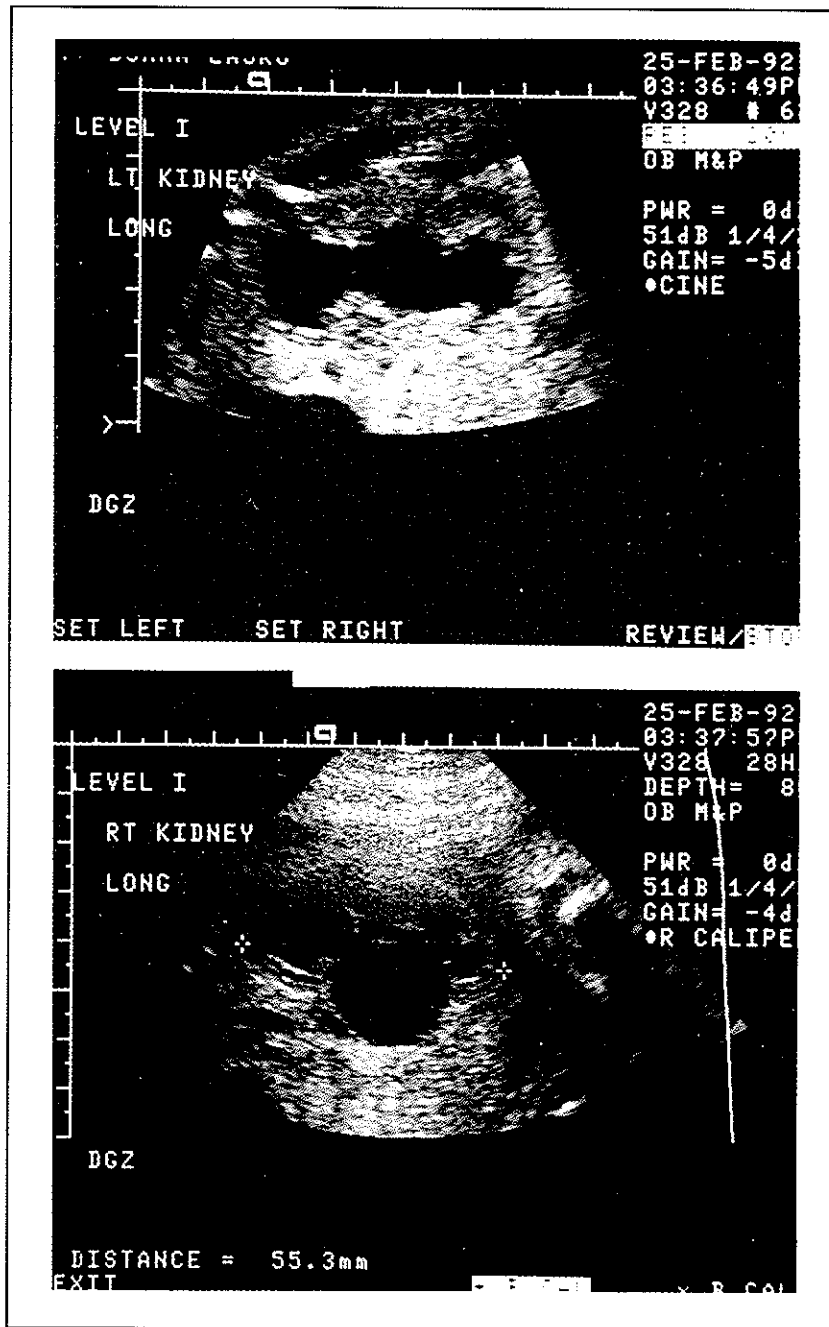


Fig. 1. Prenatal ultrasonography. Bilateral hydronephrosis was detected during a routine obstetric ultrasound. May. 1992.

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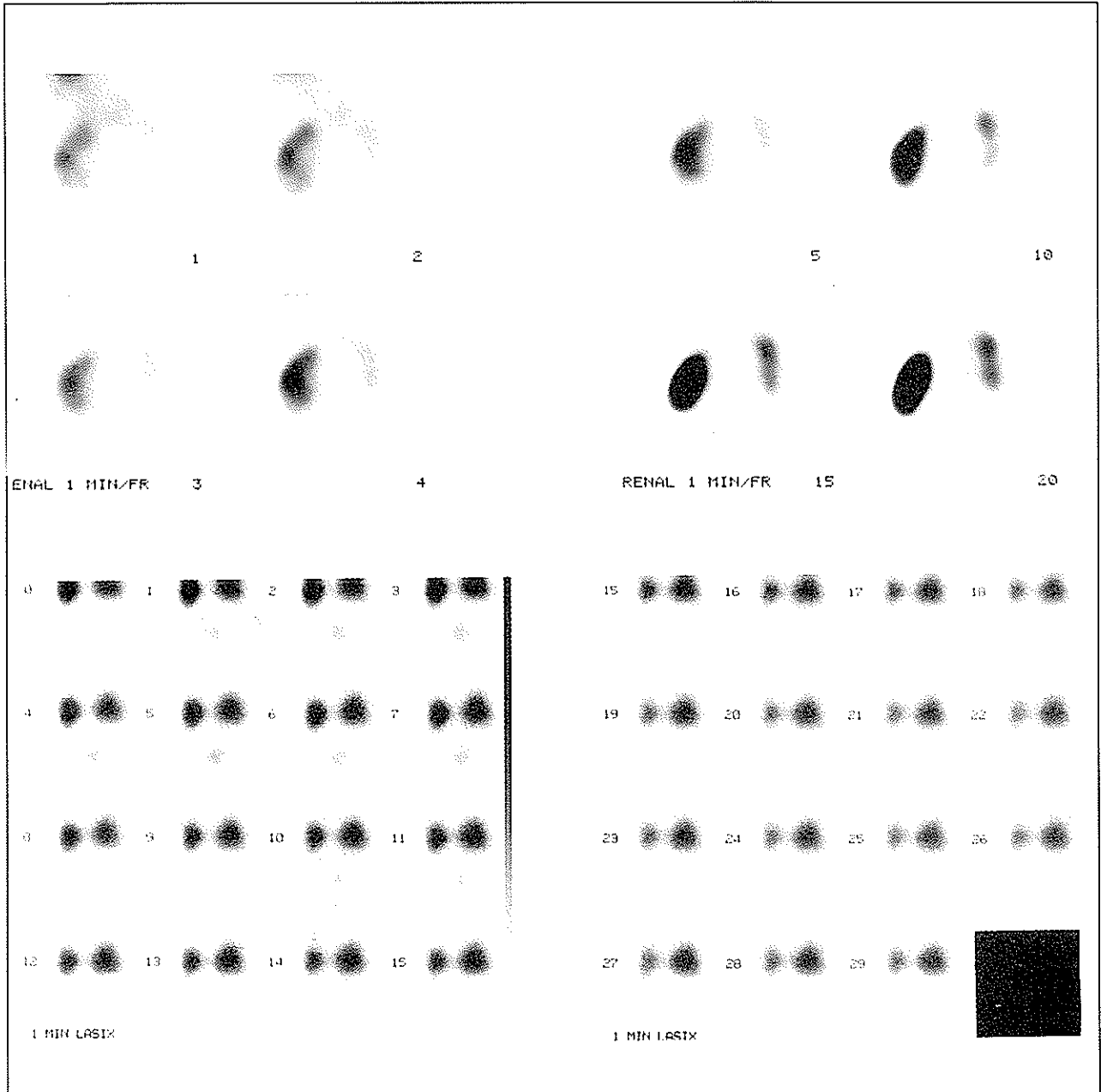


Fig. 2. Diuretic radionuclide renography. Decreased perfusion and uptake is visualized in the right kidney. Urinary activity has remained in the renal pelvis at 20 minutes bilaterally. The stasis in the left kidney has been cleared partially after lasix administration. The right renal stasis has failed to respond to lasix with no significant clearance over 30 minutes. May, 1992.

Intravenous pyelography (IVP) showed severe bilateral pyelocaliectasis which was greater on the right side. The left ureter at the ureteropelvic junction abruptly tapered. The

distal left ureter was not visualized on the 2 1/2 hour film. The right ureter was never demonstrated with certainty (Fig. 3).

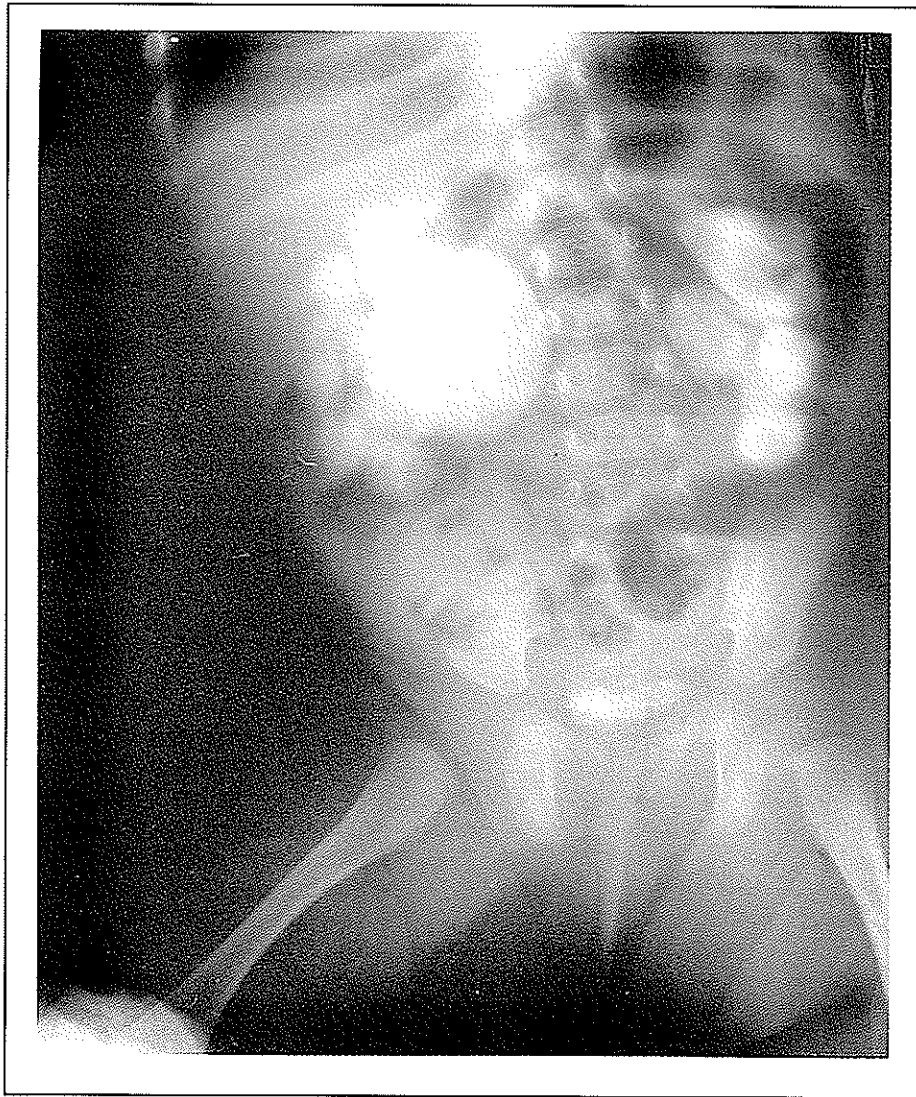


Fig. 3. Intravenous pyelography. Severe bilateral pyelocaliectasis is noted which was greater on the right side. The left ureter at the ureteropelvic junction is abruptly tapered. Note that the right ureter was never demonstrated with certainty. May, 1992.

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The Findings in aggregate were most consistent with a diagnosis of bilateral UPJ obstruction. The patient subsequently underwent right pyeloplasty without complication. Diuretic renography was performed post-pyeloplasty in July,

1992. Bilateral stasis of activity was again noted at 20 minutes. There was a significant improvement in clearance of the right side stasis following diuresis with lasix. The washout T1/2 remained prolonged in the left kidney (Fig. 4).

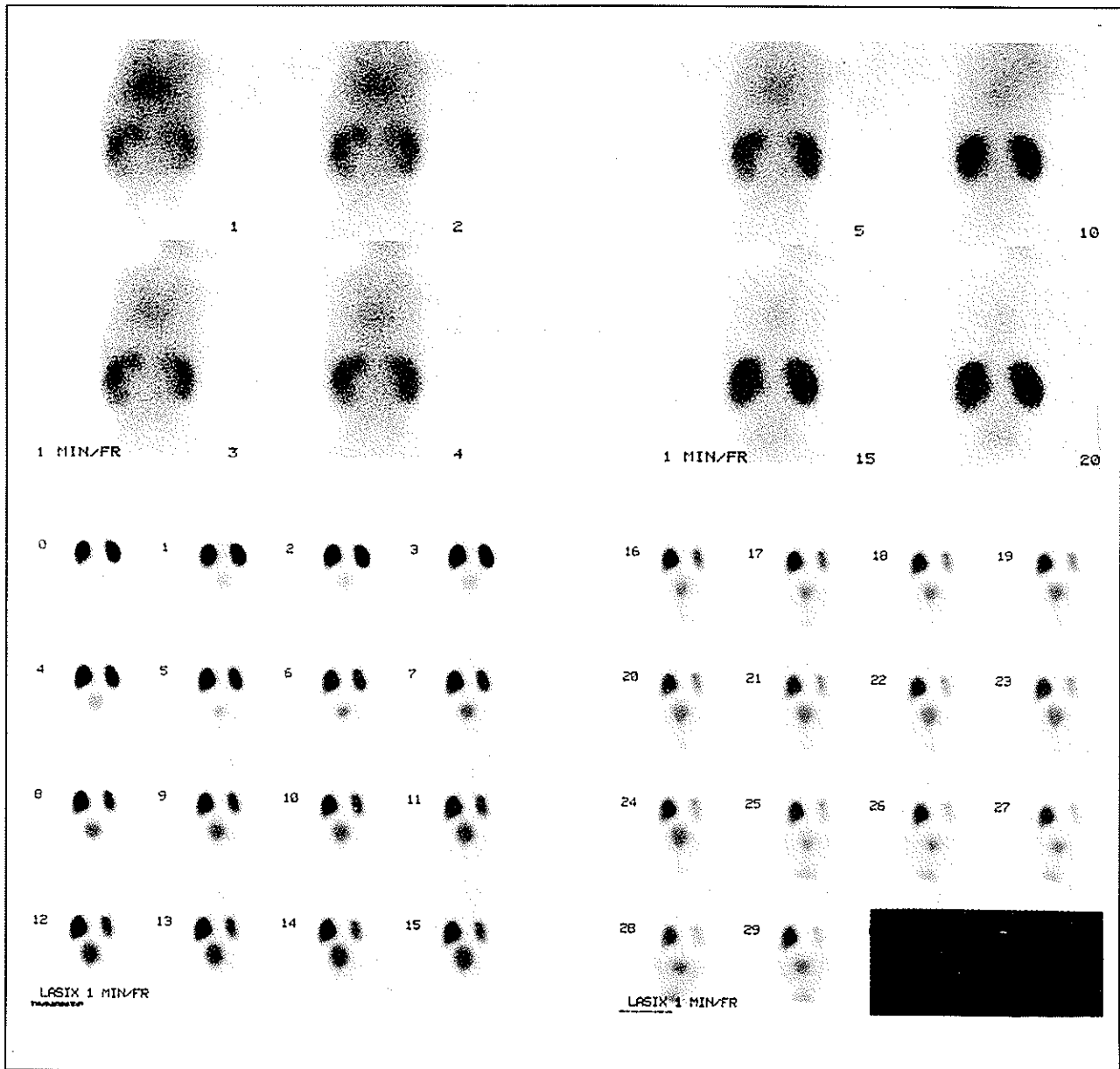


Fig. 4. Diuretic renography after pyeloplasty. Bilateral stasis of activity is noted at 20 minutes. There is a significant improvement in clearance of the right side stasis following diuresis with lasix. Note that the washout T1/2 remained prolonged in the left kidney. July, 1992.

The normalized uptake in the left and right kidneys was 2.3% and 1.6%, respectively. Improvement in the right renal uptake following surgery was felt to be due to improved renal function. Although the left kidney washout T1/2 remained prolonged, there was no

deterioration in the normalized uptake value. The patient's left kidney was observed without urgent surgical intervention. A follow up diuretic renogram in January 1993 demonstrated persistent obstruction in the left kidney (Fig. 5).

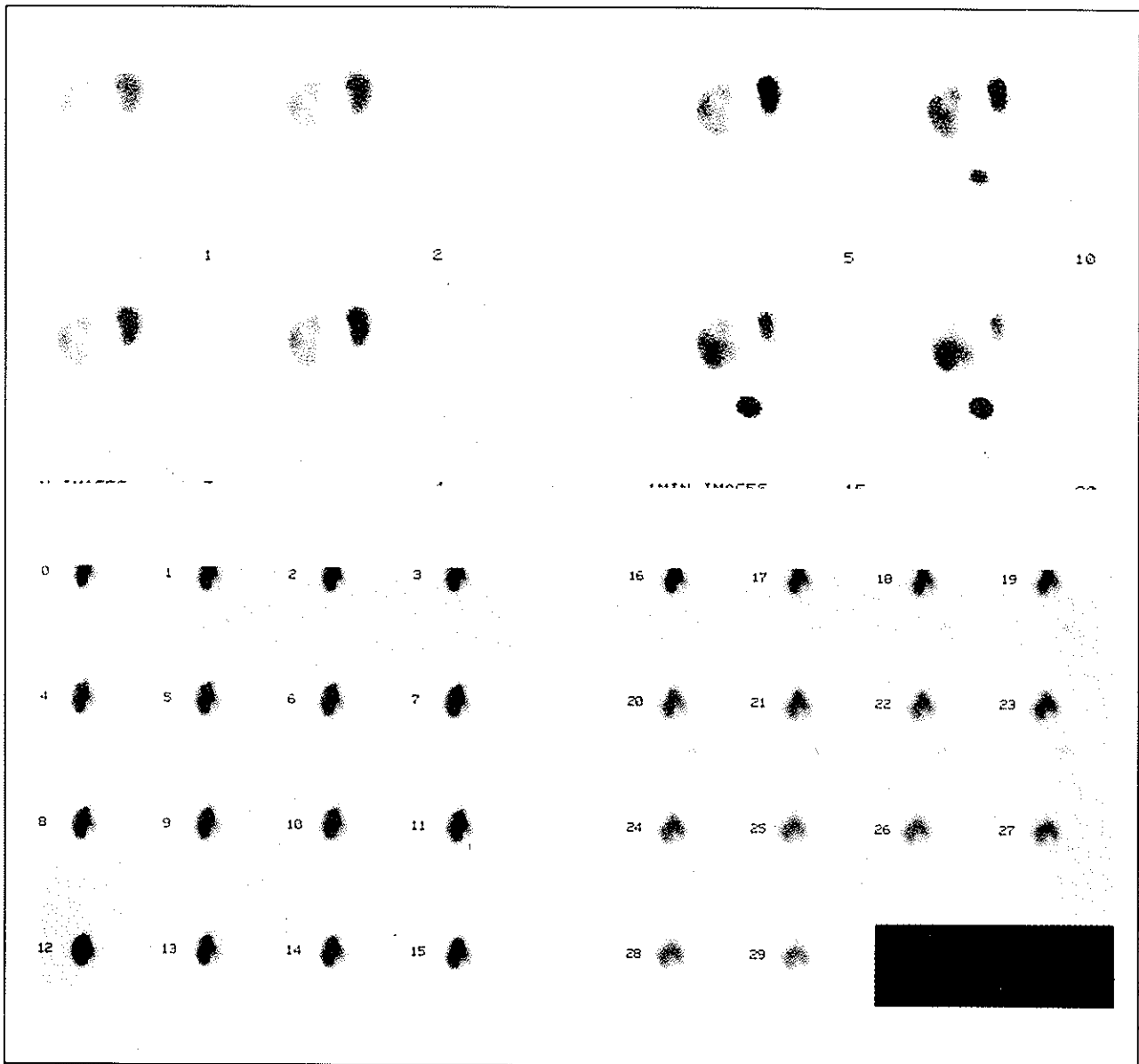


Fig. 5. Follow up diuretic renography. Persistent obstruction is noted in the left kidney. January, 1993.

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The normalized uptake in this kidney decreased to 1.4% from its most recent value of 2.3 in July, 1992. A left pyeloplasty was subsequently performed. A diuretic renography was

performed following surgery and demonstrated significant improved in both the normalized uptake (1.85%) and the drainage ($t_{1/2} = 2$ minutes) of the left kidney (Fig. 6).

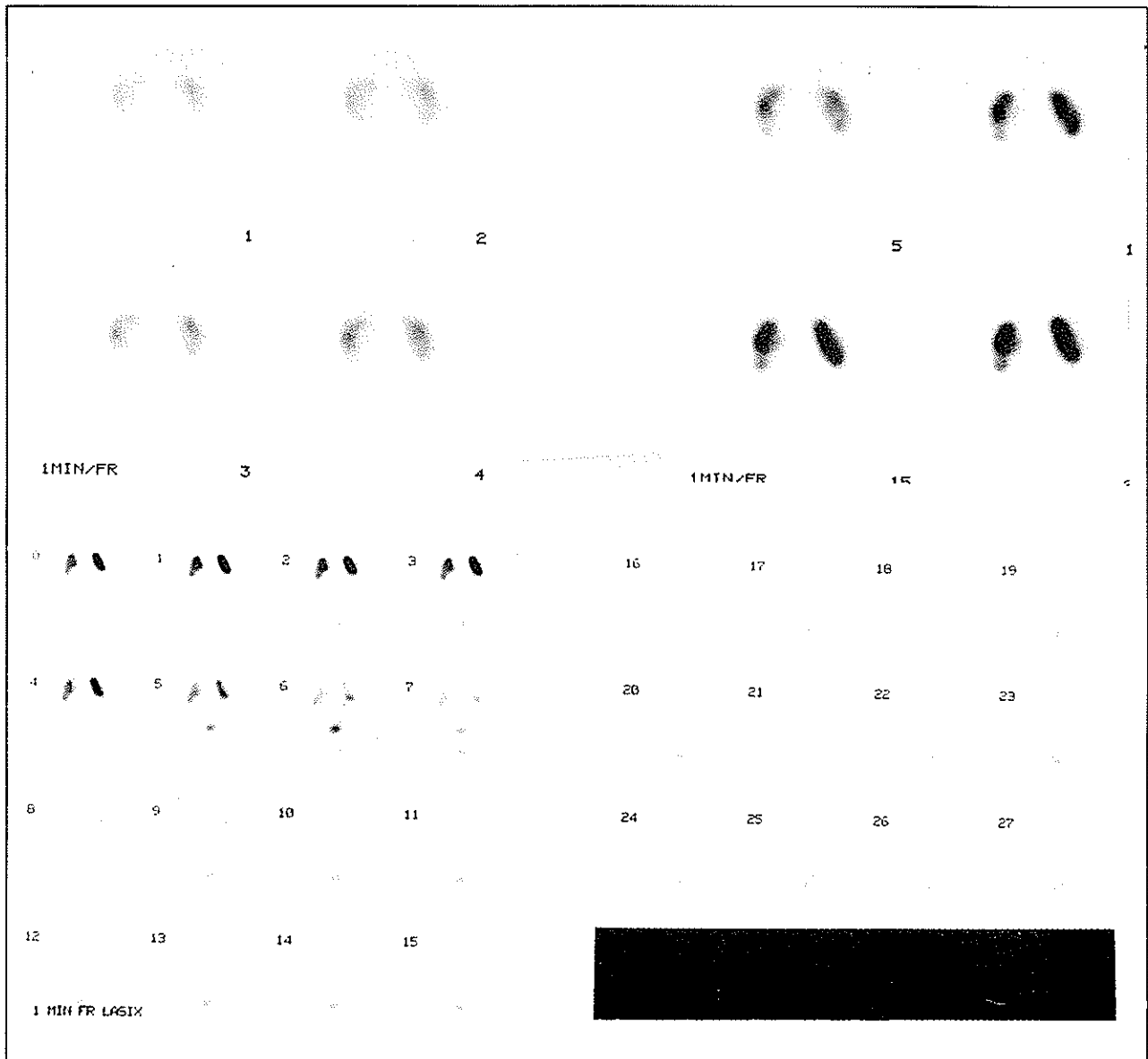


Fig. 6. Diuretic renography following left pyeloplasty. Significant improvement in both uptake and clearance of the left kidney is visualized following surgery.

An IVP showed both UPJs were widely patent (Fig. 7).

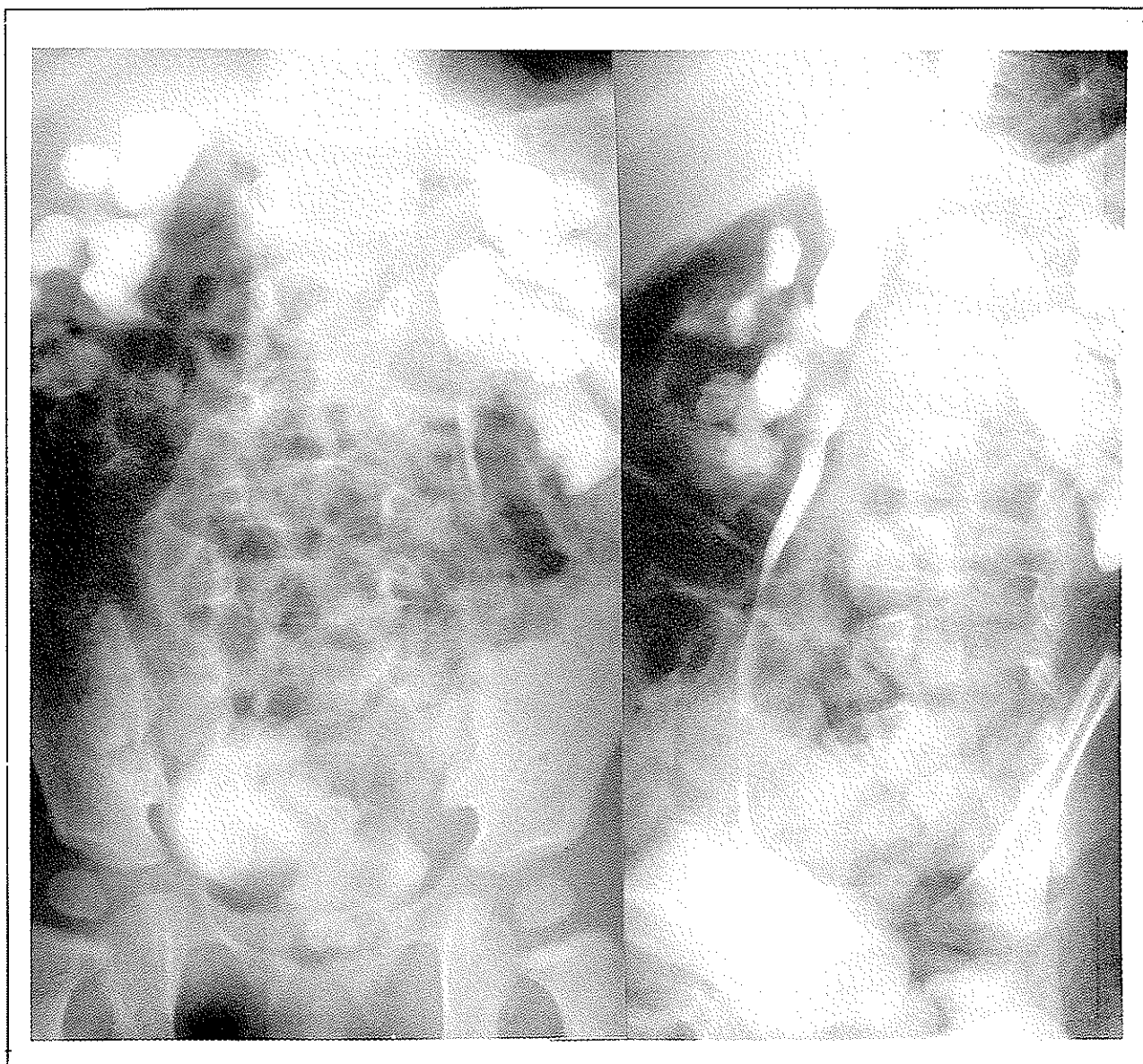


Fig. 7. Interavenous pyelography. IVP shows both UPJs are widely patent.

CASE TWO

A newborn male was referred to our institution for the evaluation of antenatal left hydronephrosis. A VCUG was performed at 3 weeks of age showed no evidence of vesico-ureteral reflux. A radionuclide

renography demonstrated a dilated left kidney with a thin rim of functioning cortical tissue. Stasis was evident in the left kidney with a diuretic washout T1/2 greater than 20 minutes (Fig. 8).

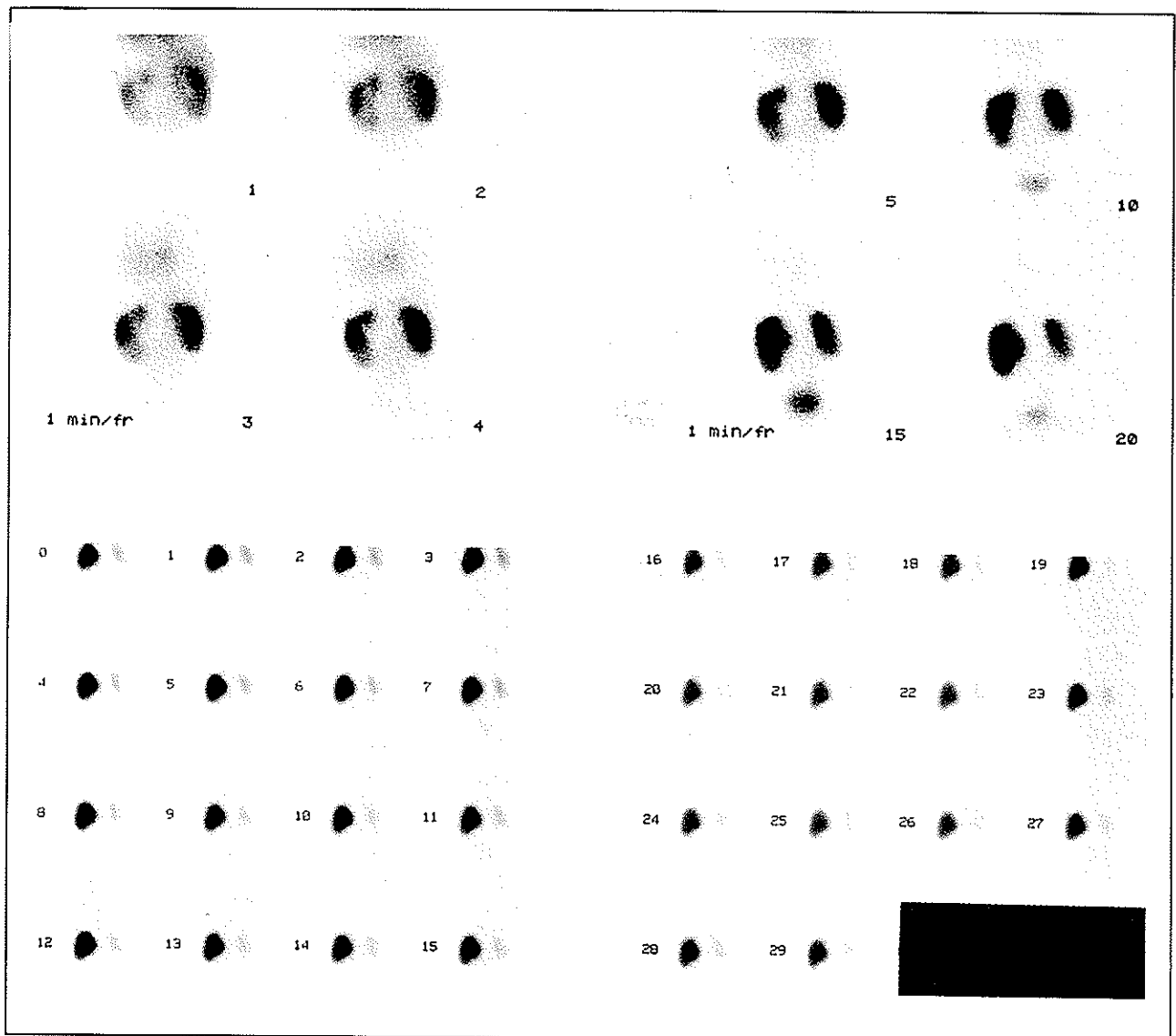


Fig. 8. Diuretic renography. There is a dilated left kidney with a thin rim of functioning cortical tissue. Stasis is evident in the left kidney with a diuretic washout T1/2 greater than 20 minutes.

The normalized uptake in the left and right kidneys were 1.8% and 2.2%, respectively. No surgery was performed at this time as the patient had a normal normalized uptake. At seven months of age, a follow up diuretic renography demonstrated persistent urinary

stasis at 20 minutes. This residual activity cleared rapidly after the administration of lasix (Fig. 9). The normalized uptake in the left kidney was 1.8% and represented stable renal concentrating function. The patient remained well without surgical intervention.

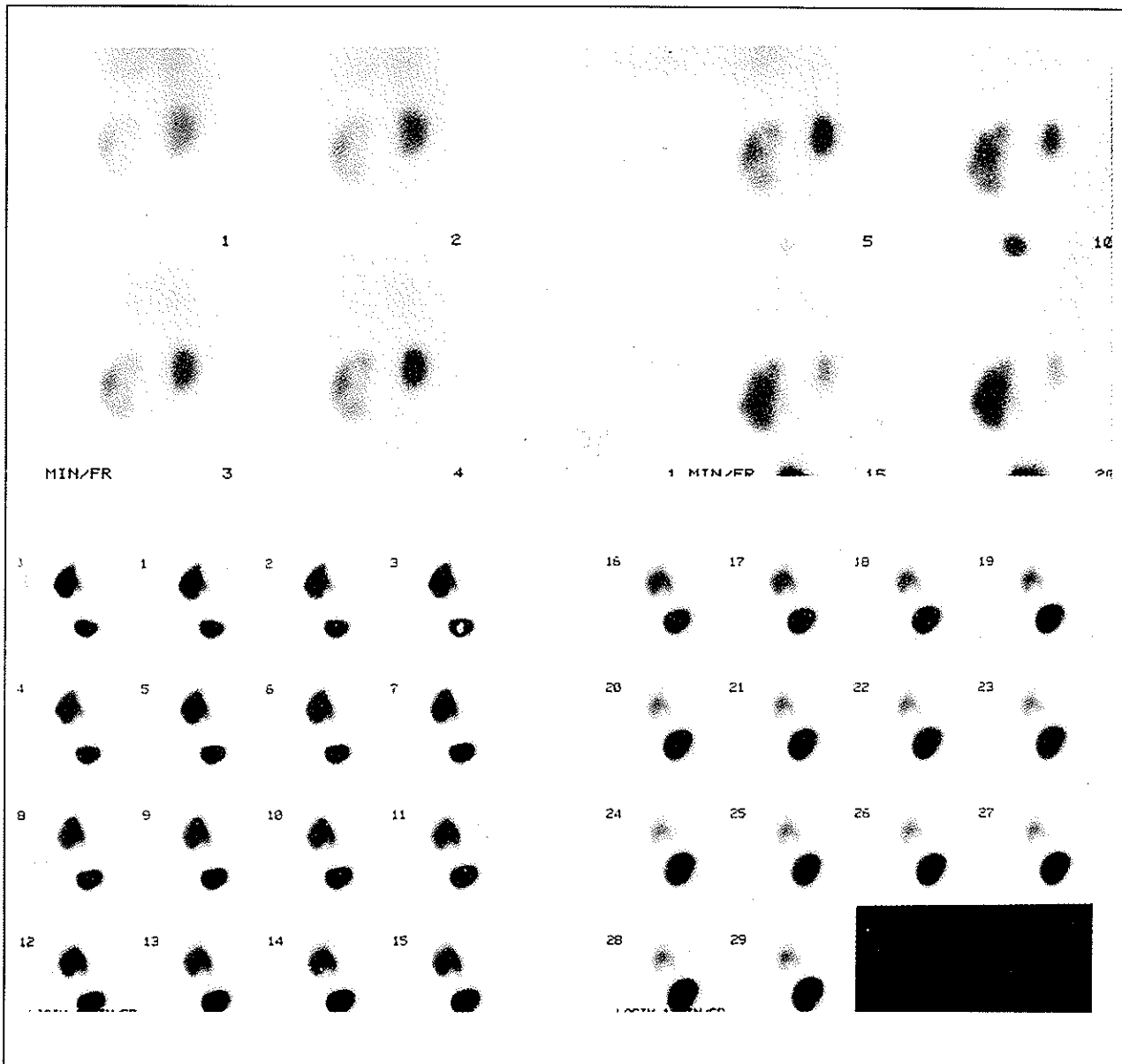


Fig. 9. Follow up diuretic renography. Persistent urinary stasis is noted at 20 minutes which is cleared rapidly after administration of lasix.

DISCUSSION

The incidence of fetal hydronephrosis has been estimated to be 0.2 to 0.4% prior to the advent of the widespread application of prenatal US (Scott, Helin). In the past, only the most obstructed patient were evaluated for surgical intervention. These patients presented with a palpable abdominal mass or urinary tract infection. The increasing use of routine maternal ultrasound has tremendously increased the number of patients referred for evaluation of hydronephrosis. The common causes of congenital hydronephrosis are listed in Table 1.

Ureteropelvic junction (UPJ) obstruction remains the most common cause of hydronephrosis in children (Young, McGrath). This is also the most common congenital anomaly of the urinary tract. The characterization of this disorder has shown that males are affected more often than females (Graverson) and the left kidney is more frequently involved than the right. Bilateral obstruction has been found in 10-30% defined. It has been described to be the result of a failure of recanalization of the metanephric cord during the fifth and sixth week of gestation (Ruano-Gil).

The diagnosis of UPJ obstruction has been made by using IVP, ultrasonography (US), and radionuclide renography. On IVP, a characteristic dilatation of the renal pelvis and calyces are demonstrated. Excretion of the contrast in the affected kidney is delayed. Radiography with images at several hours are occasionally needed to demonstrate the exact of obstruction. There are some difficulties with routine contrast radiography in the evaluation of hydronephrosis.

A poorly functioning kidney may be present coincident with high grade obstruction. Both antegrade and retrograde pyelography are occasionally required to establish the anatomic site of obstruction when the ureter is not well visualized. Occasionally, a kidney with a large extrarenal pelvis may be mistaken as UPJ obstruction. This false positive interpretation of obstruction can be avoided by insuring that the interpretation of obstruction is not made without evidence of caliectasis. The degree of ureteral filling distal to the UPJ is also variable and can lead to difficulty in interpretation. An apparent 'kink' in the proximal ureter is

another occasional cause of false positive IVP for congenital UPJ obstruction. Judicious care in searching for the aberrant vessel can usually discriminate this from a true UPJ obstruction. Lower grades of vesicoureteral reflux are also very difficult to evaluate on contrast urography. In our laboratory, a VCUG is performed in all patients with suspected UPJ obstruction to exclude vesicoureteral reflux as a cause of the hydronephrosis.

The typical US appearance of UPJ obstruction is that of a dilated Pelvo-calyceal system without ipsilateral ureteral dilation. Polycystic dysplasia may occasionally be confused with UPJ obstruction. Polycystic dysplasia is characterized by the presence of multiple cystic structures well demarcated by thin septae. Both IVP and US are unable to assess the functional significance of the obstruction and are unable to measure kidney function quantitatively. The dilated pelvis in suspected UPJ obstruction is not a specific finding. This obstruction appearance is not physiologically significant in many patients (Whitaker). A functional diagnostic test of the significance of the dilated renal pelvis is important to guide clinicians. The most appropriate imaging test following the screening and anatomic imaging is the radionuclide lasix renography.

The Whitaker pressure perfusion study (Whitaker test) was introduced in 1970 as a method to directly measure urinary obstruction (Whitaker 2). The test is invasive and requires a percutaneous pelvo-calyceal catheter. There is controversy regarding the optimal flow rate to use and the appropriate end point to use in discriminating the functional from the nonfunctional obstruction (Lupton). The Whitaker test is also hampered by the inability to measure the renal function. This technique, due to the multitude of limitation is not widely performed.

The diuretic renogram was first described by Rado et al in 1967 (Rado). Since its introduction, diuretic renography has remained useful and well utilized diagnostic test for evaluating urinary obstruction. A number of parameters for assessing obstruction have been described. These include clearance half-time (Koff), residual activity at 30 minutes (Jamar), and emptying renographic patterns (O'Reilly). The diuretic renogram is not a perfect solution

Table 1. Common cause of congenital hydronephrosis.

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| <ol style="list-style-type: none"> 1. Intimal thickening at the ureteropelvic junction producing luminal narrowing 2. Congenital stricture at the ureterovesical or ureteropelvic junction 3. Aberrant vessel or band 4. Congenital megaureter 5. Ureterocele 6. Urethral Vavles 7. Ureteral valves |
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for the clinicians. The specificity of diuretic renogram in evaluating obstruction has been challenged (gordon). The neonatal kidney is not uniformly capable of responding to lasix and has lower glomerular filtration rate than preadolescent children (koff). Conway had addressed many of these concerns. His group has been able to provide reproducible diuretic renogram in the pediatrics population with careful attention to patient preparation. They emphasized the importance adequate patient hydration, bladder catheterization, choice of radio-pharmaceutical, appropriate time of administering diuretic, and standardized method of data analysis (conway).

Two major unresolved problems in diuretic renography are abnormally prolonged T1/2 which is associated with impaired renal function and the apparent prolonged drainage of a dilated collecting system which requires a larger diuretic response to drain a larger volume (conway). This second difficulty has been partly addressed by Conway et al. This problem can be partly overcome with generous hydration and an increased lasix dose. Yung et al. has proposed another partial solution to this problem. He uses a normalized clearance-to-uptake slope ratio as a method to minimize false positive diuretic renograms. They showed an improvement in the specificity to 98%. However, the outcome was not clearly defined in their publication and this method has not yet been reproduced in another laboratory (Yung). We conducted a survey of all the neonates referred to our institution with an antenatal diagnosis of suspected UPJ obstruction from November, 1991 to December, 1992. A total of 50 patients (38 male, 12 female) were evaluated during this period. Diuretic renogram is routinely performed in all patient at the time of their first urology evaluation. The mean age at

first renogram was 1.7 months. Fourteen patients underwent surgery following the renogram (0.83 to 11.4 months). One patient had surgery on both kidneys. We calculated the normalized uptake and the washout half-time (T1/2) following the administration of lasix. We compared the normalized uptake values and (T1/2) between the kidney which subsequently underwent surgery with those managed medically (Fig. 10).

There was a statistically significant difference in both the normalized uptake and the T1/2 in kidneys which subsequently underwent surgery in comparison with those managed with medical treatment alone ($p < 0.007$ and 0.0005 , respectively). We propose several possible explanations for these obstruction. In our institution, surgery was performed for several reasons: a) deteriorating renal function, b) urinary tract infection or c) symptoms of colic. The clinicians make a decision to perform surgery partly based on the finding in diuretic renogram as well as the normalized uptake value. This incorporates a significant selection bias into our sample population. In Figure 11, two kidneys underwent surgery reimplantation of the ureter although they had a normal T1/2. Eight kidney with T1/2 more than 20 minutes were managed conservatively. These patient had a normal stable normalized uptake. The T1/2 was not the major determinant in these kidneys for the decision concerning the need for surgery. There was a clear association of prolonged T1/2 with subsequent surgery. We found the predictive value of the T1/2 and the normalized uptake were approximately equal in importance.

The normalized uptake and T1/2 are both good predictors for the surgical endpoint in this group of patient. It is difficult to determine the best apportionment of the predictive value of

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these two variables in this retrospective review series. A prospective study would optimally be utilized to answer this question.

The natural history of the patient with congenital UPJ obstruction is not yet fully characterized. The function in these hydronephrotic kidney is variable. The function

may remain stable or even improve unless a complication such as infection, obstruction or stone formation occur (gordon). The best way of managing these patients remains a controversial issue (cartwright, mandell, Josephson, Ransley).

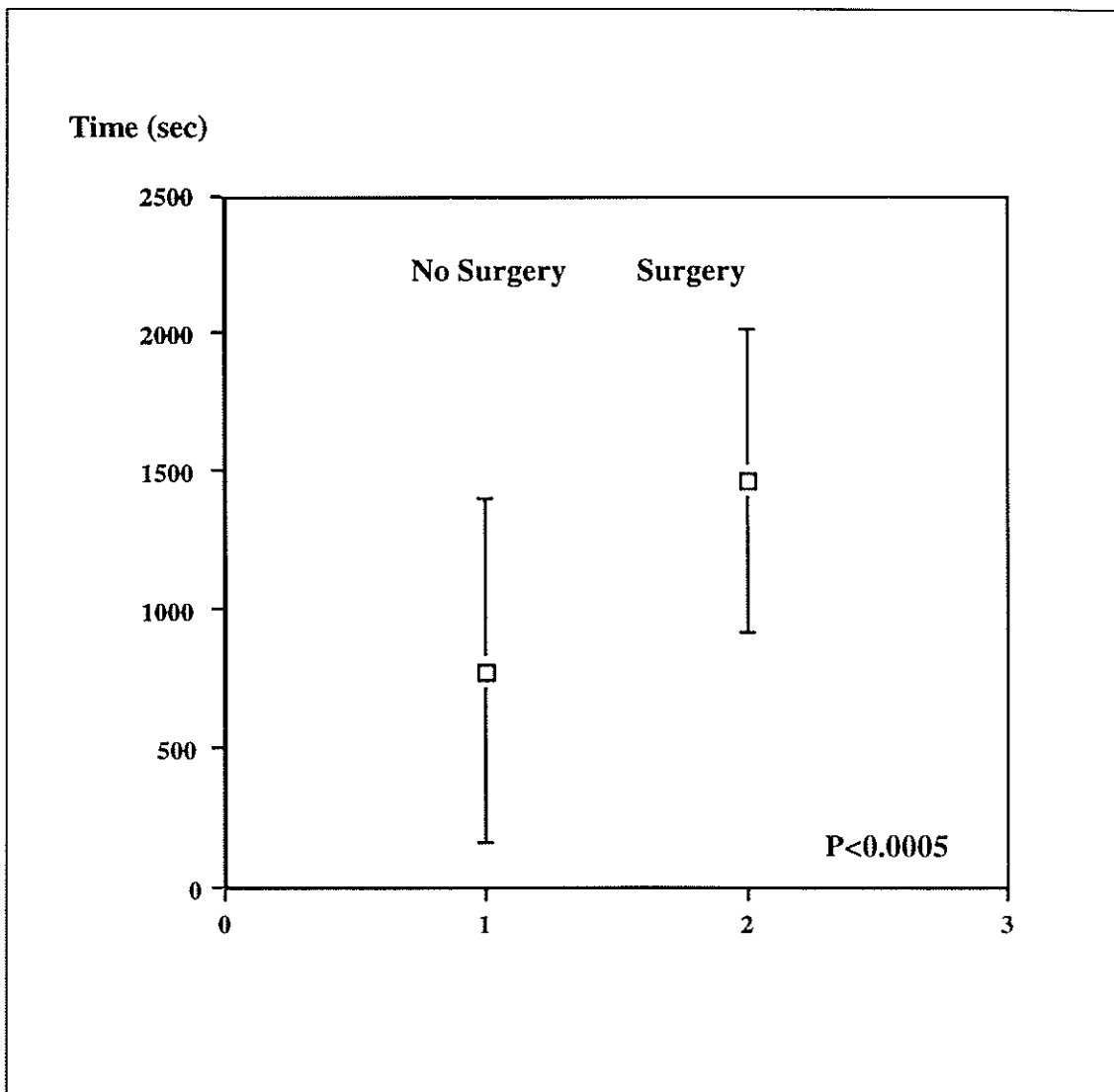


Figure 10A. Lasix washout T1/2 (Mean \pm SD)

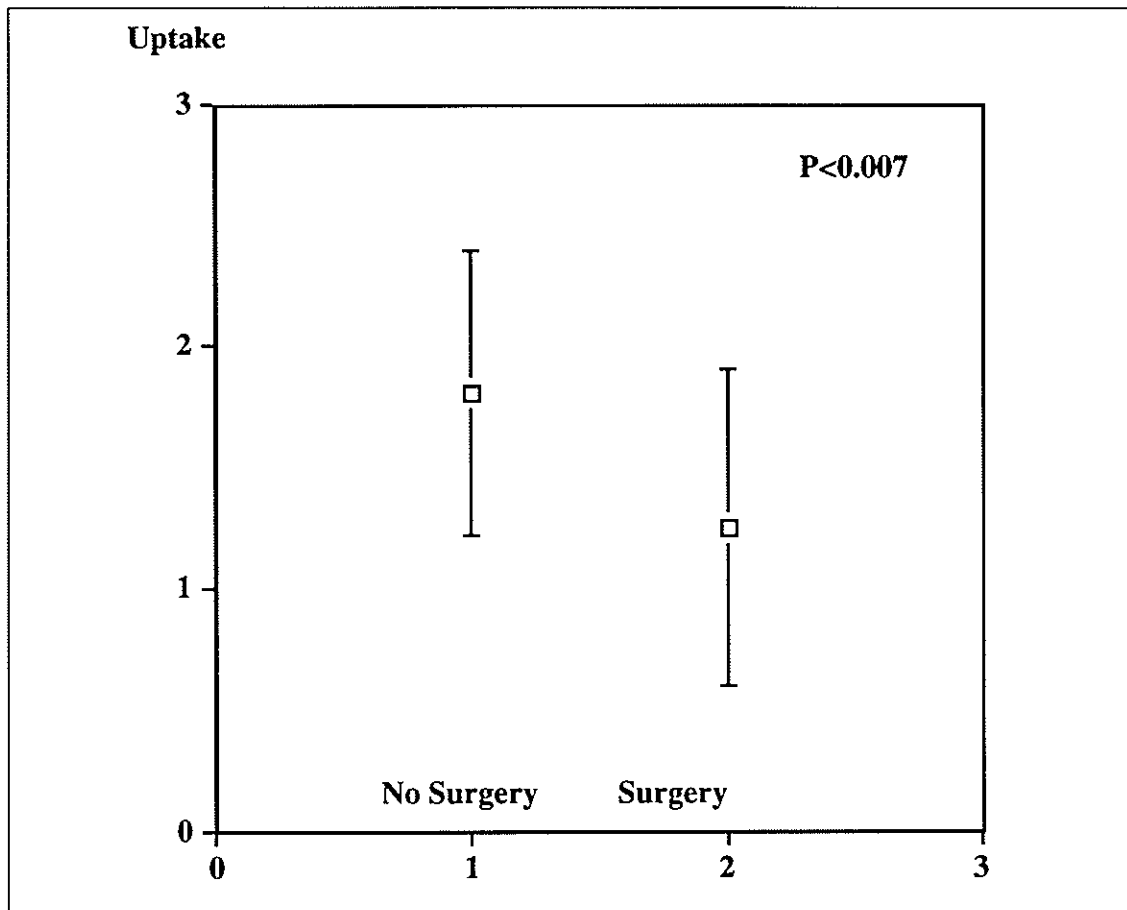


Figure 10B. Normalized Uptake (Mean \pm SD)

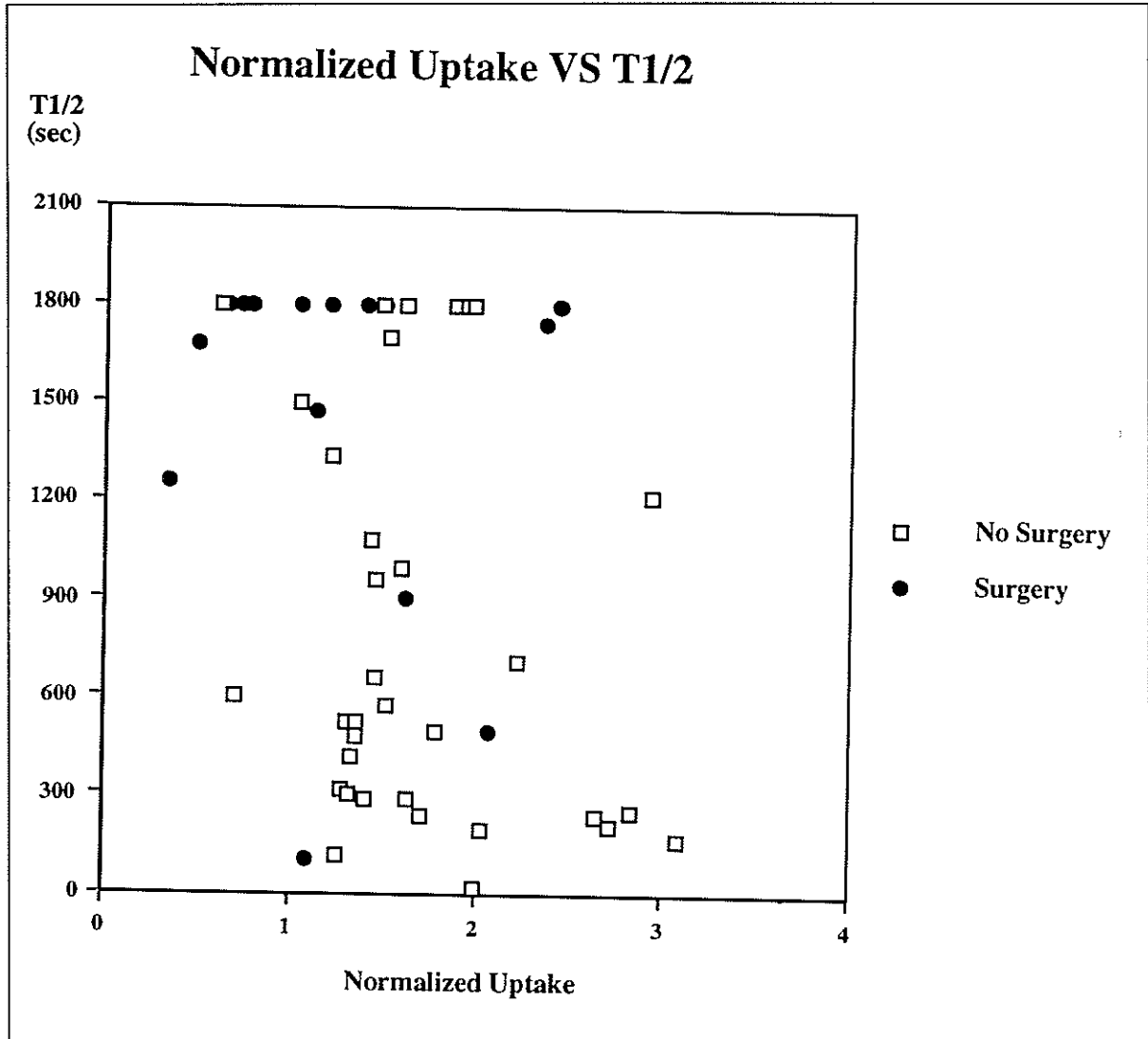


Figure 11. Normalized Uptake VS T1/2

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