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Differential renal function in the prediction of recovery in adult obstructed kidneys after pyeloplasty

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Aim: Pyeloplasty is a widely accepted method for the treatment of ureteropelvic junction obstruction (UPJO). Surgery has long been thought to affect postoperative renal function. However, controversies still exist on the functional studies that can be used to indicate which renal units will benefit from surgery. In this study, the correlation between differential renal function (DRF) and other preoperative parameters was examined to determine which parameter more accurately predicts recovery of renal function in adult obstructed kidneys. ***Materials & Methods:*** In this study, the authors evaluated 32 patients with UPJO. In all patients, standart diuretic Tc-99m DTPA renal scans were performed preoperatively and 6 months after surgery. Patients were divided into two groups according to the preoperative DRF (≥ 30%, n = 22, group I and < 30%, n = 10, group II). Second type classification was made according to the postoperative DRF improvement as improved (group A, n = 13) and not improved (group B, n = 19). These groups were then compared regard to variables which were defined as symptoms, age at operation and ultrasonographic findings. We also evalulated whether preoperative parenchymal function is important to predict improvement in drainage half-time (T1/2). ***Results:*** While preoperative drainage half-time was 39.6 ± 15.9 minutes, postoperative half-time decreased to 16.9 ± 6.8 minutes ($p < 0.001$). The mean DRF did not improved significantly after surgery compared with preoperative values (32.03 ± 9.42% versus 36.16 ± 9.60%). When comparing the patients with preoperative DRF ≥ 30% (group I, DRF 38 ± 0.8%) to those who had an initial DRF below 30% (group II, DRF 22.8 ± 5.2%), postoperative DRF was 41.22 ± 5.72 in group I and 25.00 ± 6.22 in group II. The difference was significant ($p < 0.01$). The patients in group I and II showed improvement in 50% and 20%, respectively. Age, clinical presentation and ultrasonographic findings did not affect functional outcome after pyeloplasty. We could not find any correlation between preoperative DRF and the degree of improvement in T1/2. ***Conclusion:*** Renal function improves after pyeloplasty with regard to the initial level of split renal function in adult obstructed kidneys. Improvement may not be observed especially in patients with DRF less than 30%.

Key words: ureteropelvic junction obstruction, renal function, pyeloplasty

INTRODUCTION

Ureteropelvic junction obstruction is defined as an obstruction of the urine flow from the renal pelvis to the proximal ureter. The resultant back pressure within the renal pelvis may lead to progressive renal damage. Pyeloplasty is an effective surgical treatment for UPJO. This procedure has a success rate between 72% and 95% in contemporary series.[1–4]

The goal in treating patients with UPJO is to improve renal drainage and to maintain or improve renal function. Surgery on the UPJO has long been thought to affect postoperative renal function, but not all kidneys show improvement after surgery. Also preoperative assessment of which kidneys will benefit from such surgery

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remains unreliable. There are conflicting data in the literature on the functional outcome after pyeloplasty and factors influencing improvement. Although reduced preoperative function was reported to be an important factor influencing postoperative outcome in some studies, this has been questioned in others.[5–9] Also the concept of early surgery is accepted by some authors to preserve renal function as much as possible.[10–12] There are a lot of studies in pediatric patients, but the studies including adults are limited.[13–15]

In view of the existing controversies regarding the functional outcome after pyeloplasty, we evaluated the renograms of adult obstructed kidneys. We analyzed which factors are responsible for improvement and whether a correlation between renal function and improvement on drainage half-time exists.

MATERIALS AND METHODS

Thirty-two consecutive patients with UPJO were included in the study. Patients were excluded if they had bilateral ureteropelvic junction obstruction, a solitary kidney, vesicoureteral reflux, or other bladder or ureteral abnormalities. There were 17 male and 15 female patients. The age range varied from 22 to 56 years (median 36.5). Fifty-nine percent of the affected kidneys were on the left side. Main clinical presentation was recurrent urinary tract infection in 15 patients and flank pain in 17 patients.

All the patients underwent conventional, stented, Anderson-Hynes pyeloplasty. In general, the surgery indications were a combination of an obstructed renogram curve with flank pain or pyelonephritis, loss in differential function of greater than 10% on serial renogram, a differential function of less than 40% in a single renogram, and progressive dilatation on sequential ultrasound, respectively. All patients underwent renal scintigraphic examination with Tc-99m DTPA in a standardized manner before and 6 months after the operation. Hydration was achieved by ingestion of 400 m*l* water 30 minutes before the renal scan. After injection of 185–370 MBq of Tc-99m DTPA bolus injection in the supine position, dynamic acquisition was performed using an Elscint SPX-6 gamma camera equipped with an all purpose, low energy collimator. Data were collected at 30 second intervals. 0.5 mg/kg furosemide was given intravenously after radiotracer was visualized in the dilated renal pelvis at the conclusion of 20 minutes of dynamic image acquisition or on later static images. For all renograms, the quantitative measurement of the drainage half time was calculated using standard computer generated curves from the renal region of interest measured by using the average slope of the first component of the washout curve. Renogram curves were evaluated according the original description by O'Reilly et al.[16]

Region of interest was drawn around each kidney. Background was based on a further ROI drawn around the renal ROI and separated from it by one pixel. Time-activity curves were generated from the all ROIs, and background-corrected renal curves were generated. Slope method (the slope of linear regression of the renogram) was used to derive DRF values from the curves of the

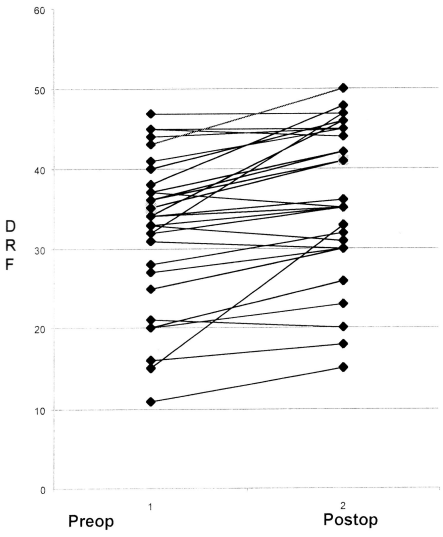

Fig. 1 Preoperative (preop) and postoperative (postop) changes in DRF (differential renal function) in all patients.

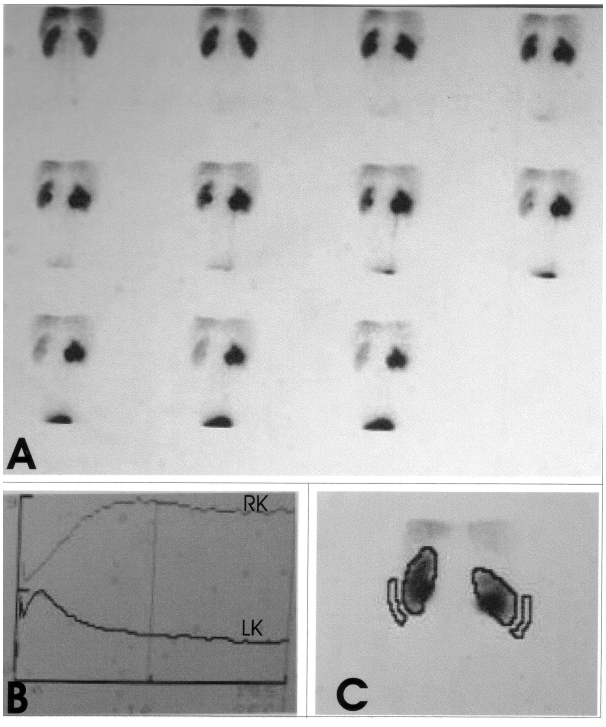

Fig. 2 Preoperative renal scintigraphy images in a 32-year-old patient (A). Renogram shows obstructive pattern and no drainage after diuretic administration (B). Differential renal function was 61% in the left kidney and 39% in the right kidney. LK = left kidney, RK= right kidney.

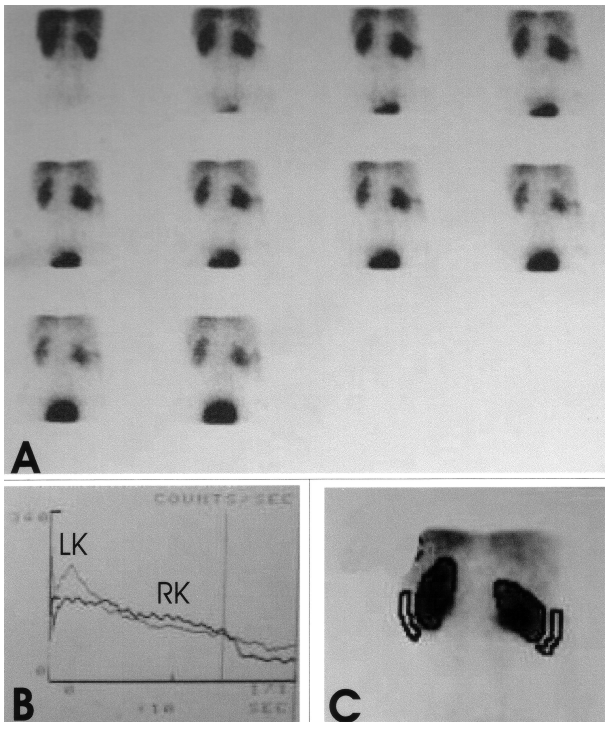

Fig. 3 Postoperative renal scintigraphy in same patients (A). Renogram shows improvement in drainage (B). Differential renal function was increased from 39% to 44% in the right kidney. LK = left kidney, RK = right kidney.

Table 1 Comparison of various parameters between group A and group B

Parameter	Group A n = 13	Group B n = 19	P
Age at surgery	36 ± 8.9	37 ± 9	NS
Symptoms			
Infection	6	9	NS
Pain	7	10	NS
Preoperative DRF	32.7 ± 8.0	31.53 ± 10.4	NS
Parenchymal thickness (mm)	7.3 ± 1.1	7.2 ± 1.0	NS

NS = not significant.

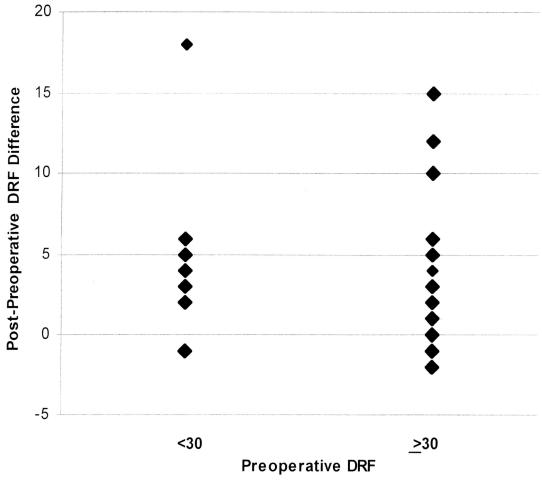

Fig. 4 Comparison of DRF in group I and group II. Post-preoperative DRF = postoperative-preopertaive DRF.

ROIs obtained during the 2–3 minutes after radiopharmaceutical injection. The patients were classified on the basis of two parameters: 1. Those with preoperative split renal function greater than 30% (group I, n = 22) or less than 30% (group II, n = 10). An increase in the differential function of the operated kidney by over 5% was considered significant, and these kidneys were accepted as improved. According to the postoperative DRF changes further division was made as improved (group A, n = 13) and not improved (group B, n = 19).

Ultrasound was performed with a real time linear array and a 3.5 MHz probe or a sector scanner with a 5.0 MHz probe and each assessment was reviewed in a blind fashion by one physician who was unaware of the renal function of the affected kidneys. An ultrasound grading classification based on the relative thickness of the renal parenchyma, size of the renal pelvis and caliceal dilatation was used.[17] We used parenchymal thickness (<or> 5 mm) as a variable. Ultrasound examination closest to the date of the Tc-99m DTPA renal scan was used for comparison.

All values were expressed as mean plus or minus standard error. Pairwise comparisons were assessed by the paired or unpaired t, Wilcoxon signed rank or Mann-Whitney U test with $p < 0.05$ considered significant. Multivariate logistic regression analysis of clinical, scintigraphic and ultrasonographic covariables was undertaken to determine which factors predicted surgical outcome. Statistical analyses were done using commercially available software.

RESULTS

In the study, all postoperative scans showed good drainage without signs of obstruction. Preoperative and postoperative drainage half-times were 39.6 ± 15.9 minutes and 16.9 ± 6.8 minutes, respectively. A significant difference between these two values was noted ($p < 0.001$).

The mean DRF did not improve significantly after surgery compared with the preoperative value (32.03 ± 9.42% versus 36.16 ± 9.60%, $p < 0.335$) (Fig. 1). DRF showed significant improvement in 13 patients (Figs. 2, 3), no significant change (within 5% of the preoperative value) in 14 patients, and a deterioration in 4 patients. When we compared group A with B, median patient age at surgery was 36 years (range 22 to 55) and 37 years (range 28 to 56), respectively with this difference not significant (p: 0.893).

When comparing the patients who had preoperative DRF ≥ 30% (group I, n = 22, DRF 38 ± 0.8%) with those who had initial DRF below 30% (group II, n = 10, DRF 22.8 ± 5.2%), postoperative DRF was 41.22 ± 5.72 in

group I and 25.00 ± 6.22 in group II and the difference was significant ($p < 0.01$). Fifty percent of the patients in group I and twenty percent in group II showed improvement (Fig. 4). According to the preoperative DRF values (below < 30% and ≥ 30%) postoperative improvement of drainage half time showed no significance between group I and group II. There was no correlation between initial DRF and improvement rate in drainage time.

Preoperative USG revealed parenchyma less than 5 mm thick in none of the patients in group A and in 2 in group B, both of whom showed a decrease in postoperative DRF. Parenchymal thickness was a median 7.3 mm (5.8–9.8) in group A and and 7.2 mm (5.5–9.3) in group B. We could not find any significant difference between these two groups related to the USG findings. There was no significant difference in postoperative percent differential renal function when cases were categorized according to clinical presentation. There was no statistical correlation between the age at surgery and the occurrence of a significant change in postoperative DRF. A comparison of parameters between groups A and B were given in Table 1.

DISCUSSION

We evaluated diuretic renograms at 6 months following pyeloplasty. Our findings concurred with previously reported results of significant improvement in drainage. Pohl et al. showed that the rate of improvement after pyeloplasty correlates with the degree of preoperative obstruction based on drainage half-time on diuretic renogram. They also found an improvement in half-time in 84% of patients.[18] Tapia et al. showed significant improvement in drainage in 86% of their patients.[5] In the present study, all patients had an improvement in drainage half-time (< 20 minutes).

Several studies have attempted to determine the functional outcome of pyeloplasty, usually with indeterminate or conflicting results. Early surgery has been recommended to achieve renal recovery. Roth and Gonzales recommended that pyeloplasty be performed before a patient age of 1 year, since maturation of renal function is more rapid in the first 6 months of life and levels off at 2 years.[19] Mayor and others support this concept of early repair. They supported the improvement potential of the affected kidney might change in different stages of life.[20] Chandrasekharam et al. stated that following pyeloplasty both infants and those below 1 year of age demonstrate significant improvement compared to older children. Postoperative DRF could reach a normal value (over 40%) only in those below 1 year of age. They concluded that the potential recovery of the kidney depends on age.[21] Poulsen et al. observed age associated functional improvement, particularly in kidneys with differential function less than 20%.[22] Our observation of an improvement in DRF and age at surgery is the same as MacNeily et al.'s. They reported that increasing patient age does not affect functional outcome after pyeloplasty.[23] Our study comprised only adults and the changes in postoperative per cent split renal function were not affected by the age at surgery. The patient's age was not predictive of the potential for improvement in our study. Older age did not preclude the possibility of improvement after pyeloplasty.

With regard to functional improvement of the obstructed kidneys, our results to some extent differ from certain other reports on adult kidneys. Despite improved drainage half time, the mean DRF for obstructed kidneys was not improved at follow-up, but kidneys with a DRF more than 30% preoperatively improved significantly after pyeloplasty. Danuser et al. reported that in their 80 adult patients, renal function was unchanged 6 and 24 months postoperatively despite decreased dilatation.[24] Our results indicated that pyeloplasty improved the function in 40% of patients and provide stability or prevent deterioration of renal function in 87.5%.

There is no consensus about the preoperative renal function which may predict functional outcome.[5–7,9,10] With the advent of prenatal ultrasonography, management of hydronephrosis has changed considerably and the studies focusing on pediatric patients have become of greater interest than those focusing on adults. Our results showed that renal function improved after surgery related to the initial level of DRF. Patients with initial DRF over 30% revealed an increase in DRF after surgery whereas patients with initial DRF less than 30% did not. In the present study, 13 renal units showed improved renal function after pyeloplasty, 10 had initial DRF ≥ 30%. Chandrasekharam et al. showed that kidneys with initial DRF below 30% were showed significant improvement than the kidneys with initial DRF over 30%. An initial DRF over 40% was associated with little or no improvement.[16] In contrast, we found a high improvement in patients who had initial DRF greater 30% compared with those with less than 30%. Two patients who had a DRF over 40%, showed further improvement. One of the seven patients with preoperative DRF > 40% showed a decrease in DRF but it was not below 40%. Four of 14 patients who did not show improvement had a DRF > 40% in preoperative evaluation. Therefore, patients with normal DRF (> 40%) could not achieve further improvement and it may not be more realistic to expect further increases in patients with a normal preoperative percent split renal function. Salem et al. also observed that only kidneys with impaired preoperative function improved after pyeloplasty. But they did not define a cut-off value for DRF improvement.[13] In contrast, Mc Aleer et al. showed that renal function did not improve after pyeloplasty regardless of the initial level of renal function.[14] But in this study, mean DRF was 41% and it may explain their conclusion. Gupta et al. reported a drop in the success rate from 93% to 54% when preoperative split function was more than 40% versus less than 25%.[1] O'Reilly and associates demon-

strated that the greatest potential recovery often will be found in patients with the greatest pre-existing functional deficit. At decompression the parenchyma regains a more normal disposition and recovers useful function.[25] Niemczyk et al. reported that patients with renal function greater than 35% demonstrated functional improvement after surgery and that none of the patients with renal function less than 30% showed postoperative functional improvement.[10] In the present study, three of 10 patients who had initial DRF < 30% showed improvement of function (33.3%), while eleven of the 22 patients with initial DRF ≥ 30% showed an improvement (50%). Niemczyk's report comprised only adults with an age range of 19–67 years which was similar to that of our group, but the other discussed reports included pediatric subjects, and therefore this discordance may be due to different improvement rate in children and adults. Reports on adults are few, and most concern improved symptoms and intravenous pyelography. Bratt et al. studied 78 adults and only 12 patients showed an improvement after surgery.[26] Poulson reported a significant improvement after surgery in 10 of 17 adults with initially low function.[22] Our study demonstrated that improvement was related to preoperative function. Kidney compensation in adults may not be as impressive as in children. Hence, most of the renal units which initially showed relatively high DRF demonstrated greater improvement. Kinn et al. studied GFR and ERPF in patients with UPJO 5–7 days after surgery and 2–5 years later.[7] They concluded that the functional improvement was not sufficient to be of clinical importance. Bratt and coworkers studied GFR with Cr 51 EDTA or inulin and DRF by DTPA in 78 adults with UPJO and showed some improvement in renal function in 12 of 17 patients with preoperative decreased renal function, but they did not use a 5% cut off value for improvement.[26] It is not entirely clear what value was used for improvement. O'Reilly reported that preoperative function was decreased in 18 patients, improved postoperatively in 10 and remained the same in 8 with the degree of improvement being greatest in patients with the most severely depressed preoperative levels.[25] Their study group was small and they did not a make a classification with regard to DRF, with poor renal function defined as a relative value.

In another recent study of O'Reilly et al., the long-term results of pyeloplasty after a mean of 10.6 years were evaluated, and 19 of 24 adults had an improvement in DRF. The median improvement ranged from 32% to 44%, but the authors accepted as improved all kidneys demonstrating an increase without using a cut off value of 5%. In that study, there were 5 patients who showed an increase in DRF less than 5% evaluated as improved which explains the differences between the discordant results.[27] In a recent work of Kinn et al., DRF was improved from 40.8% to 47.1% of total function after pyeloplasty in 47 symptomatic adult patients, but they did not make any evaluation regarding the preoperative DRF value.[28]

According to our results, parenchymal thickness on ultrasound was not a reliable predictor of functional outcome of surgery.

We also evaluated whether preoperative parenchymal function is important to predict the improvement on T1/2. But we could not find any difference in T1/2 values between the two groups. Our results did not concur with those of Niemczyk et al.[10] They showed that kidneys with DRF greater than 35% on the initial study improved the most on the basis of T1/2. Patients with DRF less than 30% usually did not show improvement. The discordance in these two studies may be related to the smaller number of patients in their studies in which only 8 patients were included, 4 of whom had DRF ≥ 35% preoperatively. Relatively few reports of evaluation of these two parameters together are available. Several experimental studies have demonstrated that the degree of renal atrophy cannot be reversed even by prompt surgical correction. These studies showed no correlation between the degree of dilatation and parenchymal artophy, and their conclusion was that improved drainage without improvement on renal function does not obviously justify surgery.[29]

Differential renal function appears to be a more practical and noninvasive method to evaluate functional differences after pyeloplasty. Quick estimation of DRF without reference to underlying GFR is a simple, easily repeated and useful method in clinical practice and also well accepted by patients. But the pitfalls of DRF should be kept in mind. The spectrum of its accuracy may vary based on the method chosen to calculate DRF and also may affect multiple factors such as radiopharmaceutical, injected dose, matrix size, and frame rate. There is no accepted single technique that provides an accurate estimation of DRF. Calculation of absolute renal function values such as GFR is the more accurate but requires multiple blood samples. The gamma camera techniques that do not require either plasma or urine samples are less accurate than all of the plasma methods. Methods using plasma sampling yield only global function estimates, while gamma camera methods measure both global and differential renal functions. In patient management, the question of the relative contribution of each kidney to the total renal function is often more important than the global function itself. For this reason the results are expressed in relative units (% of total function) rather than absolute units (ml/min). We used DRF in our study as a practical and easy method that could be performed in the routine and busy working of our department.

In the literature, there are some differences and sources of errors regarding preparing patients, performing study and interpreting results in patients with pyeloplasty. Also the use of different radiopharmaceuticals causes difficulties in comparison. By standard diuretic renography protocols and using the same radiopharmaceutical for each individual, and making efforts for patient hydration and

bladder drainage, the results will be more reproducible and compatible.

CONCLUSION

We observed a significant increase in posteoperative DRF in patients with preoperative DRF greater than 30% compared to DRF less than 30%. We thought the improvement was related to preoperative renal function level, and none of the discussed parameters other than DRF were found to be predictive of improvement. In adult patients the primary goal of surgery should be providing stability or to prevent functional impairment rather than to improve function especially in patients with DRF less than 30%. We believe that surgery should be considered when the diuretic renogram suggests obstruction regardless of the renal function. Because renal function may not improve after pyeloplasty especially in those with poor DRF, salvage of renal function can best be obtained by early surgery.

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