The Role of Diuretic Renography in the Evaluation of Obstructed Hydronephrosis after Pediatric Pyeloplasty

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Background: The purpose of this study was to clarify the value of renal drainage half-time in the evaluation of pediatric hydronephrosis after dismembered pyeloplasty.

Methods: We reviewed the records of 30 children who underwent dismembered pyeloplasty for unilateral ureteropelvic junction obstruction with no other associated urological abnormality. The follow-up duration was more than 5 years for all patients. Pre- and postoperative evaluation included technetium-99m dimercaptosuccinic acid (^{99m}Tc-DMSA) renal scan, technetium-99m diethylenetriaminepentaacetic acid (^{99m}Tc-DTPA) diuretic renography, and ultrasonographic examination. According to postoperative renal drainage half-time on diuretic renography, patients were divided into 2 groups: group A with normal renal drainage and group B with prolonged renal drainage for evaluation of their renal functional status.

Results: Postoperative diuretic renography revealed normal drainage (group A) in 54% of patients and prolonged drainage (group B) in 46%. The anteroposterior diameter (APD) of the renal pelvis of all patients showed improvement after pyeloplasty. There was no significant difference in improvement of the renal pelvic APD between the 2 groups. Furthermore, 92% of group A and 91% of group B maintained stable or had improved differential renal function (DRF) postoperatively.

Conclusions: Drainage half-time is not a reliable parameter for diagnosing obstructed hydronephrosis after pediatric pyeloplasty. We suggest that the renal pelvic APD and DRF should be considered when postoperative obstructed hydronephrosis is diagnosed using the criterion of prolonged renal drainage half-time on diuretic renography.

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Key words: **hydronephrosis, pyeloplasty, diuretic renography.**

Dismembered Anderson-Hynes pyeloplasty is a standard surgical treatment for ureteropelvic junction obstruction (UPJO). Successful pyeloplasty relieves symptoms and improves renal drainage, but the functional outcome after pyeloplasty continues to be debated because not all kidneys show improvement after surgery. In addition, there is considerable controversy in the literature on the final functional outcome and the factors influencing functional improvement after pyeloplasty.[1-3] We know that

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renal function deterioration may be detected by a decrease in differential renal function (DRF) on technetium-99m dimercaptosuccinic acid (^{99m}Tc-DMSA) renal cortical scan or as an increase in renal pelvic size. Obstructed hydronephrosis is usually diagnosed by prolonged drainage half-time on technetium-99m diethylenetriaminepentaacetic acid (^{99m}Tc-DTPA) diuretic renography. However, Amarante et al. reported that impaired renal drainage on diuretic renography using half-time should not be used as a sign of obstruction in children with unilateral renal pelvic dilatation.[4] According to recent studies, neither the degree of pelvic dilatation on ultrasonography nor obstruction on diuretic renography is a reliable indicator for surgery.[5,6] As surgeons, our major concern is to postoperatively recognize when the kidney remains truly obstructed after pyeloplasty. In order to detect true obstruction after pyeloplasty, we reviewed and analyzed data derived from pre-operative and post-operative results from standardized diuretic renography, cortical renal scan, and untrasonography. At the same time, we examined the reliability of diuretic renography in diagnosing obstructive hydronephrosis after pyeloplasty.

METHODS

We retrospectively reviewed the records of 30 children who underwent dismembered pyeloplasty for unilateral UPJO. Patients with bilateral disease, associated vesicoureteral reflux, or significant postoperative complications requiring reintervention were excluded from this study. The surgical indications were based on progressive enlargement of hydronephrosis, prolonged renal drainage, and deteriorating renal function. Standard Anderson-Hynes pyeloplasties with internal ureteral stent placement were performed by the same surgeon (TMW) between 1994 and 1998. Patient's ages ranged from 10 months to 10 years. Follow-up was longer than 5 years for all patients. All patients were evaluated preoperatively with renal ultrasonography and ^{99m}Tc-DTPA diuretic renography to confirm obstructed hydronephrosis. A ^{99m}Tc-DMSA renal cortical scan was also performed to assess DRF and the severity of cortical damage. Ultrasonography was undertaken during the initial examination and was repeated every 3 to 6 months after surgery. The degree of hydronephrosis was graded according to the Society of Fetal Urology (SFU) grading system, and the anteroposterior diameter (APD) of the renal pelvis was also recorded.[7] Follow-up ^{99m}Tc DMSA renal scan and ^{99m}Tc DTPA diuretic renography were obtained at 1 year, and repeated every 2 years postoperatively.

The renal cortical scan was performed 3 hours after intravenous injection of 148-259 MBq (4-7 mCi) of ^{99m}Tc DMSA. Five hundred thousand counts of anterior, posterior, and bilateral posterior oblique views were obtained with a 128×128 matrix size. The ^{99m}Tc DMSA relative differential renal cortical functions of the right and left kidneys were calculated with background subtraction of the geometric mean. An absolute increase in DRF of more than 5% in the operated kidney was considered significant.[8,9] A change in DRF of within $\pm5\%$ of the preoperative level was defined as stable renal function. The severity of cortical damage on the ^{99m}Tc DMSA renal scan was classified and scored according to a cortical damage scoring system based on previous literature.[10] The cortical damage scores included 1 for normal with no cortical damage, 2 for mild with focal cortical damage, 3 for moderate with more-general damage and greater kidney length, and 4 for severe mixing with global cortical damage with the possible inclusion of a small segment of the normal cortex. For diuretic renography, all patients were advised to drink 300 ml of water 30 min before the diuretic study to ensure adequate hydration. Imaging was performed in the supine position with the scintillation camera below the table. Data were acquired at 15-s intervals with a 15-s 64×64 matrix size. Up to 40 mg (1 mg/kg) of furosemide was injected intravenously at 20 min after injection of 185-296 MBq (5-8 mCi) of ^{99m}Tc-DTPA. Patients were asked to stand up and empty their bladders before the furosemide injection. Clearance half-time of the radioactive urine from each side of the renal pelvis was calculated with background subtraction by exponential curve fitting after the furosemide injection.[11] Clearance half-time of less than 20 min on DTPA diuretic renography was interpreted as normal renal drainage. Prolonged renal drainage was defined as a half-time of greater than 20 min.[12] Patients were then divided into 2 groups: group A with normal renal drainage and group B with prolonged renal drainage. Ultrasonographic findings, renal pelvic APD, hydronephrosis grade, DRF, and cortical dam-

age score were compared between the 2 groups. Data were analyzed using unpaired Student's *t*-test, and a p value of < 0.05 was considered significant.

RESULTS

From 1994 to 1998, a total of 30 children (20 boys and 10 girls) underwent dismembered pyeloplasty at Chang Gung Memorial Hospital, Taipei. Six patients were excluded due to loss of follow-up and/or missing renal scans. Of the remaining 24 patients, 18 underwent right-side and 6 underwent left-side pyeloplasties. The mean patient age at time of surgery was 5.2 (range, 0.8-10) years. The mean follow-up was 5.8 (range, 4.2-8) years. All reconstructed kidneys demonstrated decreased hydronephrosis on follow-up ultrasonography. On average, the renal pelvic APD had decreased by over 57% of the initial APD of the renal pelvis by 2 years after surgery. Diuretic renography at 3 years after surgery showed normal renal drainage in 13 patients (54%) and prolonged renal drainage in 11 patients (46%). In accordance with the SFU hydronephrosis grade, most patients had grade 3 (7 patients) or grade 4 (17 patients) hydronephrosis on preoperative ultrasonography. Similarly, preoperative ^{99m}Tc-DMSA renal scans revealed moderate or severe cortical damage in 21 cases (88%) (Table1). Follow-up ultrasonography showed decreased hydronephrosis in both the prolonged and normal renal drainage groups.

All 11 patients with prolonged renal drainage were monitored for at least 4 years, and none of them was subsequently diagnosed with symptomatic recurrence (flank pain, urinary tract infection, hematuria, or renal calculi). Furthermore, the DRF of the 11 reconstructed kidneys with prolonged drainage was revealed to be stable in 6 cases, improved in 4, and decreased in 1 (Fig. 1). There were no statistically significant differences ($p > 0.05$, by unpaired t-test) in age at surgery, initial renal pelvic APD, initial DRF, initial cortical damage score, or improvement in renal pelvic APD between the 2 groups (Table 2). The small sample size is a possible reason for the lack of statistical significance. Postoperatively, DRF improved in 10 patients (42%), remained stable in 12 (50%), and deteriorated in only 2 (8%). Actually, 1 of the 2 patients with deteriorated renal function had a normal drainage half-time. Thus, the kidney with unimproved renal function did not correlate with poor drainage in our series. Overall, 92% of patients, who included those with improved or stable renal function, had good DRF after surgery. The degree of DRF improvement ranged from 5.2% to 12.8% (mean $\pm$ SD, 10.2% $\pm$ 2.7%). A high proportion of patients with improved or stable DRF was found not only in group A (12/13, 92%) but also in group B (10/11, 91%) (Fig. 1). Moreover, none of the chil-

Table 1. Patient Characteristics according to the Status of Postoperative Renal Drainage Half-time on Diuretic Renography

	Renal Drainage	
	Normal	Prolonged
No. of patients	13	11
No. on left side	11	9
No. on right side	2	2
No. with a hydronephrosis grade of		
3	2	3
4	11	8
No. with a cortical damage score of		
2 (mild)	3	0
3 (moderate)	4	6
4 (severe)	6	5

Table 2. Comparison of Various Parameters between Normal and Prolonged Renal Drainage Groups

Parameters	Renal drainage		
	Normal	Prolonged	*p*
No. of patients	13	11	
Age at surgery (years)	4.6 $\pm$ 3.3	5.8 $\pm$ 3.3	0.24
Initial renal pelvic APD (cm)	4.6 $\pm$ 0.5	5.3 $\pm$ 1.8	0.22
Initial DRF (%)	44.7 $\pm$ 11.4	35.2 $\pm$ 14.6	0.1
Initial cortical damage score	3.2 $\pm$ 0.8	3.4 $\pm$ 0.5	0.28
Improvement in renal pelvic APD (%)	68.2 $\pm$ 14.6	56.7 $\pm$ 19.0	0.1

Abbreviations: APD: anteroposterior diameter; DRF: differential renal function.

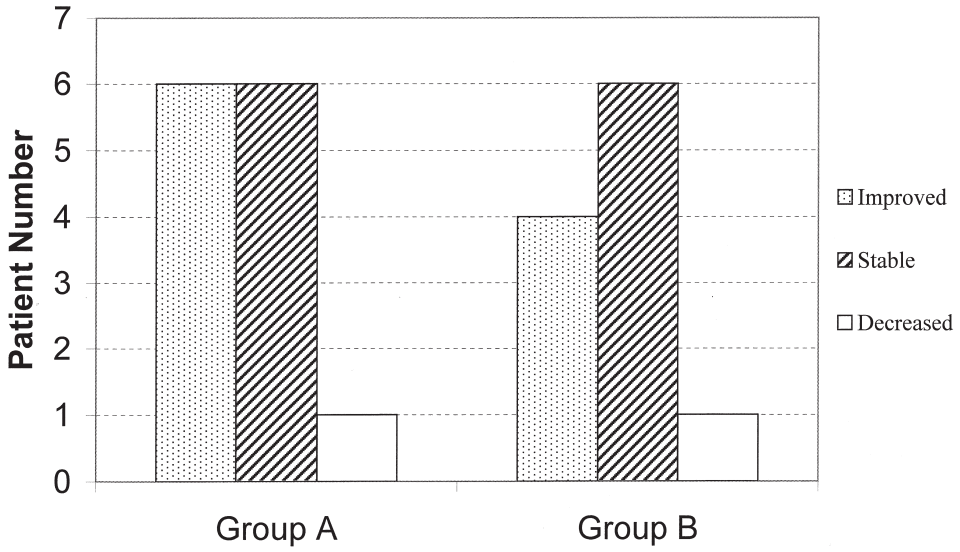

Fig. 1 Distribution of patients with respect to recovery of differential renal function after pyeloplasty in patients with normal (group A) and prolonged (group B) renal drainage.

dren required further surgery for recurrent obstruction during the follow-up period.

DISCUSSION

Several reports have advocated early relief of UPJO to allow function to recover or to prevent further loss of kidney function.[5,13] Some studies have suggested that affected kidneys with good DRF at the time of diagnosis are less likely to manifest deterioration of renal function after surgery.[3] In contrast, other series concluded that renal function did not improve after pyeloplasty, regardless of the initial level of renal function.[2] Salem et al. also observed that only kidneys with impaired preoperative function were associated with greater degrees of improvement after surgery.[9] In the study by Zaccara et al., an increase or decrease in renal function was found to be randomly distributed among patients operated upon at different ages, and the unpredictability of postoperative renal function was also emphasized.[14] Likewise, in our study, neither initial renal pelvic APD nor preoperative DRF could be used to predict which obstructed kidneys would benefit from surgery.

On the other hand, diuretic renography has been widely used to differentiate true obstructed hydronephrosis. However, some authors have questioned the interpretation of the obstructive patterns of diuretic renography and drainage half-times for the diagnosis of hydronephrosis.[15,16] The definition of obstruction based on a 20-min washout after the diuretic challenge is useful in symptomatic older children and adults, but assuming that the same criteria can be used in an asymptomatic group of young children has generated debate.[4,15,16] Therefore, some controversy has arisen concerning children with unilateral renal pelvic dilatation diagnosed by diuretic renography. One issue is the variable drainage half-time on follow-up diuretic renography, and second is the concern over interpretation of results of diuretic renography showing impaired drainage. Many institutions have reported inadequate responses to the diuretic challenge without incorporating the important factors of an empty bladder and gravity drainage in acquiring and analyzing the data.[4,17,18] It was assumed that progressive renal deterioration had begun only when there was a decrease in renal function and/or progressive dilatation of the renal pelvis.

Thus, we analyzed the group of 11 patients (46%) with prolonged renal drainage despite stable renal pelvis dilatation on ultrasonography in order to determine an underlying cause for the prolonged drainage. According to our results, DRF was stable

in 6 patients, increased in 4, and decreased in 1. In fact, the patient who presented with a postoperative decrease in DRF had a preoperative renal scan showing supra-normal renal function (SNRF) with renal function up to 77%. The problem of SNRF has previously been encountered and reported in the literature.[19] At present, the phenomenon is not well understood. Although this patient had, according to our definition, deteriorating renal function after surgery in comparison to preoperative values, the DRF had nearly returned to normal compared to the contralateral kidney. Therefore, this patient should not have been assigned to the group with decreased DRF, upon consideration of these data. In other words, all 11 patients had improved or stable DRF postoperatively.

All of the children who presented with prolonged renal drainage revealed remarkable decreases in renal pelvic APD of greater than 57%, compared to their initial ultrasonographic findings. We observed that all of the children in our study had stable hydronephrosis for at least a 5-year follow-up period with respect to pelvic size on ultrasonography and DRF on renal cortical scan. Stable hydronephrosis was considered to provide reassurance that the ureteropelvic junction remained patent unless symptoms persisted. Thus, those kidneys with prolonged drainage were considered not to have obstructed hydronephrosis. None of those children underwent surgery for recurrent obstruction during the more than 5-year follow-up period. The 11 children, with persistently impaired drainage on all of their follow-up diuretic renographies, preserved these DRFs and had stable renal pelvic sizes, representing important evidence that observations based simply upon impaired drainage may be inadequate for diagnosing postoperative obstruction.

Appropriately interpreting drainage half-time is a difficult task. The wide interpatient and intrapatient variability of renal drainage on renography may indicate that the current methods of characterizing drainage are not sufficiently reliable or sensitive parameters for diagnosing obstruction. One study, which was similar to our investigation, reported that prolonged drainage half-time and/or high-grade hydronephrosis is an indicator neither of renal obstruction nor for surgery.[20] When diuretic renography is performed, the importance of allowing the bladder to empty as well as having the patient in an erect posture has previously been described.[12,16] Improvement in renal drainage half-time after voiding and changing gravity while the patient is standing has been reported.[4,16] From our experience, drainage half-time derived from traditional diuretic renography is not a reliable factor but a relative reference. Accordingly, impaired renal drainage, in the absence of concurrent data on renal function or ultrasonography, does not appear to justify conclusion a diagnosis of obstruction. In conclusion, diagnosis of obstructed hydronephrosis cannot simply be based on prolonged renal drainage in patients with stable and asymptomatic postoperative hydronephrosis. We recommend that the renal pelvic anteroposterior diameter on ultrasonography and differential renal function on ^{99m}Tc DMSA should be taken into account when obstructed hydronephrosis is diagnosed using the criterion of prolonged drainage on ^{99m}Tc-DTPA diuretic renography.

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利尿劑核醫腎臟攝影在評估小兒腎盂整形術後的阻塞性腎水腫的角色

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背 景： 本研究的目的是在釐清核醫腎臟攝影的腎臟排泄半衰期在評估小兒腎盂整形術後的阻塞性腎水腫的價值。

方 法： 我們回溯30個沒有合併其他泌尿系統異常的單側腎盂輸尿管交接處阻塞並且接受腎盂整形術的病童的病歷記錄。所有的病童的術後追蹤時間都超過5年。術前和術後的評估包括有DMSA的核醫腎臟攝影、DTPA利尿劑的核醫腎臟攝影和腎臟超音波檢查等。根據手術後的核醫腎臟攝影的腎臟排泄半衰期，我們將病童分爲兩組來評估來其腎臟排泄功能的狀況，其中A組是正常排泄半衰期，B組是延長的排泄半衰期。

結 果： 手術後的利尿劑核醫腎臟攝影結果顯示54% (A組) 的病童是正常排泄，而46% (B組) 是排泄時間延長。其中正常排泄半衰期的A組中有92%以及延長排泄半衰期的B組中有91%的術後腎臟功能追蹤是屬於穩定或有所改善。兩組之間對於腎盂前後徑改善的比較並沒有統計學上的意義。而且所有的病童術後的腎臟超音波檢查所算出的腎盂前後徑都比術前改善。

結 論： 腎臟排泄半衰期在評估小兒腎盂整形術後的阻塞性腎水腫並不是一個相當可靠的指標。我們建議在評估阻塞性的腎水腫時除了參考腎臟排泄半衰期之外應該同時考慮到腎盂前後徑的大小以及個別腎臟功能的比例。

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關鍵字： 腎水腫，腎盂整形術，利尿劑核醫腎臟攝影。

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