Role of Ultrasonography and Dynamic Renal Scintigraphy Parameters in Decision Making Regarding Performance of Pyeloplasty in Children with Ureteropelvic Junction Obstruction

Üreteropelvik Bileşke Darlığı Olan Çocuklarda Piyeloplasti Kararı Verilmesinde Ultrasonografi ve Dinamik Böbrek Sintigrafisinin Rolü

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ABSTRACT

Objective: There are conflicting results regarding the time of surgical treatment in patients with ureteropelvic junction obstruction (UPJO). Therefore, we aimed to compare the predictive power of ultrasonography (USG) and dynamic renal scintigraphy parameters in the diagnosis and treatment of UPJO.

Material and Methods: Patients diagnosed with UPJO between 2015 and 2020 were evaluated retrospectively, other congenital urinary anomalies were excluded. Renal pelvis anteroposterior diameter (APD) was evaluated by USG and staged according to the Society for Fetal Urology grading system. In dynamic renal scintigraphy, time to reach maximum renal activity (Tmax), time to clear half of the maximum activity (T1/2), differential renal function, and diuretic response were recorded.

Results: A total of 59 patients were included. Thirteen of 59 (22.0%) patients underwent pyeloplasty. The frequency of high-grade hydronephrosis and renal pelvis APD was higher in the pyeloplasty group than in the non-pyeloplasty group. In addition, Tmax and T1/2 were significantly longer in the pyeloplasty group than in the non-pyeloplasty group ($p<0.010$). Binary logistic regression analysis revealed that only increased renal pelvis APD was independently associated with pyeloplasty ($p = 0.030$; odds ratio = 1.2). An APD of 21.5 mm was the best cutoff value to identify patients requiring pyeloplasty. The sensitivity and specificity were 84.0% and 87.0%, respectively

Conclusion: Our findings suggest that USG and dynamic renal scintigraphy are useful tools for determining whether to perform pyeloplasty in patients with UPJO. Furthermore, APD can be a reliable, easy, and inexpensive method for follow-up and treatment.

Key Words: Child, Hydronephrosis, Kidney pelvis, Ultrasonography

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ÖZ

Amaç: Üreteropelvik bileşke darlığı (UPD) olan hastalarda cerrahi tedavinin zamanı konusunda çelişkili sonuçlar bulunmaktadır. Bu nedenle UPD tanı ve tedavisinde ultrasonografi (USG) ve dinamik böbrek sintigrafisi parametrelerinin öngörücü gücünü karşılaştırmayı amaçladık.

Gereç ve Yöntemler: 2015-2020 yılları arasında UPD tanısı alan hastalar geriye dönük olarak değerlendirildi, diğer konjenital üriner anomaliler dışlandı. Renal pelvis ön-arka çapı USG ile değerlendirildi ve Fetal Üroloji Derneği'nin derecelendirme sistemine göre evrelendi. Dinamik böbrek sintigrafisinde maksimum böbrek aktivitesine ulaşma süresi (Tmax), maksimum aktivitenin yarısının temizlenmesine kadar geçen süre (T1/2), diferansiyel böbrek fonksiyonu ve diüretik yanıtı kaydedildi.

Bulgular: Çalışmaya 59 hasta dahil edildi. Elli dokuz hastanın 13'üne (%22) piyeloplasti yapıldı Piyeloplasti grubunda (%22) piyeloplasti yapılmayan gruba göre yüksek dereceli hidronefroz tesbit edildi ve bu grupta renal pelvis ön-arka çapı daha fazlaydı. Ayrıca piyeloplasti grubunda Tmax ve T1/2 değerleri piyeloplasti yapılmayan gruba göre anlamlı derecede daha uzundu ($p<0.010$). İkili lojistik regresyon analizi, yalnızca renal pelvis ön-arka çap artışının piyeloplasti ile bağımsız olarak ilişkili olduğunu ortaya çıkardı ($p = 0.030$; olasılık oranı= 1.2). Piyeloplasti için en uygun renal pelvis ön-arka çap eşik değeri 21.5 mm olarak belirlendi. Duyarlılık ve özgüllük sırasıyla %84.0 ve %87.0'di.

Sonuç: Bulgularımız USG ve dinamik böbrek sintigrafisinin UPD olan hastalarda piyeloplasti yapılıp yapılmayacağının belirlenmesinde yararlı araçlar olduğunu göstermektedir. Ayrıca, pelvis ön-arka çapı ölçümü takip ve tedavide güvenilir, kolay ve ucuz bir yöntem olabilir.

Anahtar Sözcükler: Çocuk, Hidronefroz, Renal pelvis, Ultrasonografi

INTRODUCTION

Ureteropelvic junction obstruction (UPJO) is an anatomical or physiological impairment of urine outflow from the renal pelvis to the ureter. It is one of the most common causes of unilateral hydronephrosis, and its incidence is estimated to be 1/750-2000 (1-4). UPJO may cause hydronephrosis, urolithiasis, urinary tract infection, and end-stage kidney damage (5, 6). These complications can be prevented by early diagnosis and treatment. Therefore, ultrasonography (USG) and dynamic renal scintigraphy are frequently used for diagnosis and follow-up. Urinary USG is the first and most commonly used diagnostic method to evaluate the ureteropelvic junction (7-9). Dynamic renal scintigraphy is a non-invasive technique that is used to evaluate urinary system obstruction. Furthermore, it is commonly used to determine surgical intervention, clinical monitoring, and treatment effectiveness. It may also help distinguish transitory hydronephrosis cases from permanent ones (10, 11).

In this study, we aimed to assess demographical characteristics, ultrasonography (USG), and dynamic renal scintigraphy parameters of pyeloplasty and non-pyeloplasty patients with UPJO.

MATERIALS and METHODS

In this retrospective study, we enrolled 59 patients diagnosed with UPJO between 2015 and 2020 at a tertiary hospital. We excluded patients with insufficient data, ureteral dilatation, duplex kidney, fusion anomalies, solitary kidney, vesicoureteral reflux, and posterior urethral valve obstruction. This study was approved by the ethics committee of Health Sciences University Ankara Training and Research Hospital (482- 05/11/2020). We obtained written informed consent from all patients. The study was performed in accordance with the 1964 Declaration of Helsinki and its later amendments.

The demographic characteristics (such as age and sex) and clinical characteristics (such as UPJO location) of the patients were recorded. All patients who had undergone dynamic renal scintigraphy and renal USG for the diagnosis of UPJO were included in the study. Renal pelvis anteroposterior diameter (APD) was evaluated to USG and staged according to the Society for Fetal Urology (SFU) grading system. The maximum APD of the renal pelvis was measured on a transverse renal image. SFU grades 1 and 2 were considered low grades, and SFU grades 3 and 4 were high grades (12). For dynamic renal scintigraphy, adequately hydrated child were advised to void immediately prior to the renogram and the scintigraphic images were acquired with the patient supine on the imaging table for 40 minutes in the prone position. The acquisition was started after the injection of mercaptoacetyltriglycine (MAG 3) (TechneScan, Nepha, Ankara, Turkey) labeled with 99 mTc injected through the intravenous line. A furosemide dose of 1 mg/kg (maximum 20 mg) was injected through the intravenous line at 20th minute of the acquisition. During the diuresis phase, the patient was shifted to the prone position. In dynamic renal scintigraphy, time to reach maximum renal activity (Tmax), time to clear half of the maximum activity (T1/2), differential renal function (DRF), and diuretic responses were recorded. Tmax is the time period required to reach the maximum renal activity. Tmax<5 min is considered normal and Tmax>20 min is considered a very delayed transit (13). T1/2 is the time required for renal uptake to be reduced by 50.0%. T1/2<10 min is considered normal, T1/2 between 10 and 20 min is considered borderline or undetermined, and T1/2>20 min is considered an obstruction. Differential renal function (DRF) was evaluated between the first and second minutes after radioisotope injection and was expressed in terms of the extraction value. The normal level of extraction was between 45.0% and 55.0%. (5) Diuretic response of the renogram curve is graded as 1 when there is no response to furosemide; as 2 delayed excretion with partial response to furosemide; 3 delayed excretion with complete response to furosemide; 4 normal excretion with complete response to furosemide (14).

Finally, patients who underwent pyeloplasty identified and their data were recorded. Indications for pyeloplasty were based on the following protocol:

1. Worsening of hydronephrosis, characterized by an increase in the transverse APD of the renal pelvis with or without change (increase) of SFU grade on repeat ultrasounds,
2. Deterioration of differential renal function (DRF) >10% on repeated renal scans,
3. Initial renal function <40% associated with an obstructive (ascending) a curve on renogram,
4. Worsening of hydronephrosis associated with a T1/2 time >30 min,
5. Development of symptoms (sepsis, febrile urinary tract infections, stones) (15,16).

Statistical analysis

All statistical analyses were performed using the Statistical Package for the Social Sciences for Windows (version 21.0; IBM Corp, Armonk, NY). The Kolmogorov–Smirnov test was used to assess data normality. An independent samples t-test was used to compare the groups. Categorical variables were compared using the chi-squared test. Binary logistic regression analyses were used to assess factors influencing treatment modality (pyeloplasty vs. non-pyeloplasty). Receiver operating characteristic (ROC) curves were used to determine the cut off APD for selecting patients requiring pyeloplasty. Statistical significance was set at p <0.050, and odds ratios (ORs) and 95.0% confidence intervals (CIs) were determined.

RESULTS

A total of 59 patients diagnosed with UPJO were included. The mean patient age was 73.5±60.9 months. Thirty-seven (62.7%) patients were boys, and 22 (37.3%) patients were girls. Hydronephrosis was observed on the right-side in 24 (40.7%) patients and on the left side in 35 (59.3%) patients. In terms of the SFU grade, 23 (39.0%), 21 (25.6%), 13 (22.0%), and two (3.4%) patients had grades 1, 2, 3, and 4 hydronephrosis, respectively. In terms of the severity of hydronephrosis, 44 (74.6%) patients had low-grade hydronephrosis and the 15 (25.4%) patients had high-grade hydronephrosis.

Among the 59 patients, 13 (22.0%) underwent pyeloplasty. Eight of 13 patients who had pyeloplasty were diagnosed after 3 years of age. Of these patients, 2 had flank pain and hematuria, 3 had flank pain and urinary tract infection, and 3 had flank pain only. The patients undergone pyeloplasty based on symptomes and radiological findings. Other 5 patients were diagnosed in the antenatal period and undergone pyeloplasty as a result of worsening of hydronephrosis in the first year of life. Table I summarizes the characteristics of patients, overall and according to the groups (pyeloplasty group vs. non-pyeloplasty group).

The groups (pyeloplasty group vs. non-pyeloplasty group) did not differ in terms of age, sex, and side of hydronephrosis (p> 0.050) (Table I). However, the number of patients with high-grade hydronephrosis was significantly higher in the pyeloplasty group than in the non-pyeloplasty group (76.9% vs. 10.9%; p = 0.010) (Table I). In addition, the renal pelvis APD was significantly higher and Tmax and T1/2 were significantly longer in the pyeloplasty group than in the non-pyeloplasty group (p< 0.010) (Table I). Furthermore, the time to respond to diuretics was significantly lower in the pyeloplasty group than in the non-pyeloplasty group (p=0.010) (Table I).

Binary logistic regression analysis revealed that among the variables that differed significantly between the pyeloplasty and non-pyeloplasty groups, only increased renal pelvis APD was

Table I: Characteristics of patients with hydronephrosis, overall and according to the groups (pyeloplasty vs non-pyeloplasty)

Characteristic	Overall patients (n=59)	Pyeloplasty group (n = 13)	Non-pyeloplasty group (n = 46)	p
Age (months)*	73±61	82±73	71±58	0.570‡
Gender†				
Boy	37 (62.8)	10 (76.9)	27 (58.7)	0.330§
Girl	22 (37.2)	3 (23.1)	19 (41.3)	
Hydronephrosis side†				
Right	24 (40.7)	7 (53.8)	17 (37.0)	0.270§
Left	35 (59.3)	6 (46.2)	29 (63.0)	
Hydronephrosis grade†				
Low-grade	44 (74.6)	3 (23.1)	41 (89.1)	0.010§
High-grade	15 (25.4)	10 (76.9)	5 (10.9)	
Renal pelvis APD (mm)*	20±9	31±9	17±5	0.010‡
Tmax*	12±9	21±9	10±6	0.010‡
Time to response to diuretics (min)*	2.5±1.0	1.6±1.0	3.0±0.8	0.010‡
Differential renal function (%)*	49±10	44±11	50±10	0.090‡
$T_{1/2}$ time (min)*	25±17	43±19	20±12	0.010‡

:** *mean ± SD,* **†:** *n(%),* **‡:The Independent sample T test,* **§:** *Chi-square tests,* ***APD =*** *Anteroposterior diameter*

Table II: Binary logistic regression analysis of patients' characteristics with respect to pyeloplasty operation

Characteristic	OR	95% CI	p
Hydronephrosis grade	12.1	0.3 – 468.0	0.180
Renal pelvis AP diameter (mm)	1.2	1.0 – 1.4	0.030
Tmax	1.5	0.9 – 2.3	0.060
Time to response to diuretics (min)	0.5	0.1 – 3.6	0.490
Differential renal function (%)	0.8	0.6 – 1.0	0.170
$T_{1/2}$ time (min)	0.9	0.7 – 1.1	0.530

***OR** = Odds ratio, **CI** = Confidence interval*

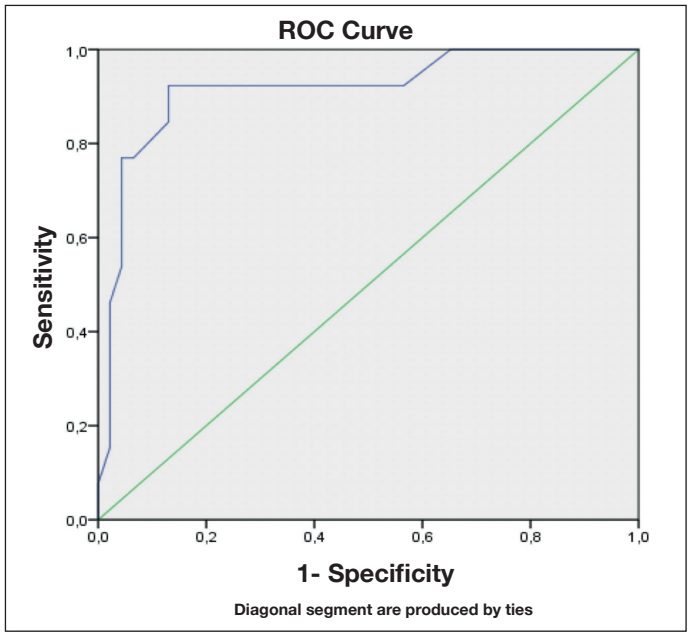

Figure 1: The Roc Curve analysis of the renal pelvis anteroposterior diameter for prediction pyeloplasty (area under the curve = 0.91; standard error = 0.05)

independently associated with pyeloplasty (p = 0.030; OR = 1.2) (Table II). ROC curve analysis revealed that the optimal cut off value of the renal pelvis APD for predicting pyeloplasty was 21.5 mm. The sensitivity and specificity were 84.0% and 87.0%, respectively (Figure 1).

DISCUSSION

UPJO is the most common congenital anomaly of the ureter and is the most common cause of antenatal and childhood hydronephrosis (17). USG is the first diagnostic procedure used to detect UPJO (5). Hydronephrosis can be detected by USG in UPJO. In a previous study, some cases were detected during the antenatal period, 65.8% cases completely regressed during follow-up without a decrease in DRF (18). Another diagnostic method is the dynamic renal scintigraphy, a safe and sensitive procedure to evaluate DRF and drainage over time (19). Many newborns and children may be asymptomatic until diagnosis. Therefore, detection during childhood is difficult (20). The silent clinical course and the socio-cultural environment may be the cause of delayed diagnosis. Hence, it is necessary to conduct an appropriate investigation at an appropriate time to visualize the urinary system and avoid unnecessary invasive procedures.

UPJO is more common in boys than in girls. It usually affects the left kidney (21). Schreuder et al. (22) claimed that this left-sided lateralization could be related to the development of the vasculature, differential gene expression profiles, or susceptibility to environmental factors, such as hypoxia. Consistent with the literature, 62.7% of the patients in our study were boys, and 59.3% of them had left kidney obstruction.

Different classifications have been used to grade renal pelvic dilatation. Most recently, Nguyen et al. (23) proposed a new urinary tract disorder (UTD) classification system. In this classification, there are six grades, stratified based on gestational age and whether the UTD is detected prenatally or postnatally. In contrast, the grading system proposed by the SFU emphasizes the extent of calyceal dilatation (24). It is still the most commonly used classification worldwide. In this study, we grouped patients according to the SFU grading system, and 25.4% of the patients had high-grade hydronephrosis. We claim that the SFU grading system demonstrated strong effectiveness in estimating the likelihood of pyeloplasty in our study. Furthermore, the frequency of pyeloplasty was seven times higher in the high-grade hydronephrosis group than in the low-grade hydronephrosis group.

In a study published by Arora et al. (25), it was reported that 23.9% of patients required pyeloplasty. The procedure was most commonly performed in patients with high-grade hydronephrosis. In our study, pyeloplasty was performed in 22.0% patients, and 76.9% of them had high-grade hydronephrosis; this finding is consistent with those of previous studies.

The most frequently used parameters to evaluate the extraction and excretion phases in dynamic renal scintigraphy are Tmax, T 1/2, and DRF (10). Krajewski et al. (5) emphasized the importance of T 1/2 longer than 20 minutes in determining significant obstruction. In the study by Çetin et al. (26), T1/2 was longer in the pyeloplasty group than in the other groups. In our study, T1/2 was significantly longer in the pyeloplasty group than in the non-pyeloplasty group (p=0.010). T1/2 time is a useful marker in determining the need for surgical intervention in patients with UPJO. In our study, it was used effectively in deciding on treatment in the pyeloplasty group.

DRF plays an important role in determining pyeloplasty in patients with UPJO. In a prospective study, Tabari et al. (27) assigned patients into two groups: early pyeloplasty and conservative management. In the early pyeloplasty group, there was a significant decrease in DRF results at 12th month. However, in the conservative management group, the renal function deteriorated both at 6th and 12th months. In a retrospective study, Yang et al. (28) reviewed 629 patients with UPJO. Patients were grouped into early pyeloplasty (DRF >40.0%) and late pyeloplasty (DRF <40.0%) groups. They found

that renal function was better in the early pyeloplasty group than in the late pyeloplasty group postoperatively. In our study, DRF was 44.5% in the pyeloplasty group and 49.6% in the non-pyeloplasty group, and the difference was not significant (p>0.090). Similar to the study by Yang et al. (28), the mean DRF was >40.0% in our pyeloplasty group. In our study, we did not categorize our patients as early or late pyeloplasty. However, we argue that the DRF value of >40.0% in the pyeloplasty group suggests that the procedure was performed at the correct time without compromising the kidney's differential function.

Prolongation of Tmax (>20 min) may indicate performing pyeloplasty in patients with UPJO (13). In our study, the mean Tmax was significantly higher in the pyeloplasty group than in the non-pyeloplasty group (21.4% vs. 9.8; p=0.010). Similar to our study, Khawaja et al. (29) reported that the mean preoperative Tmax was >19.0 in patients with UPJO. Although they found that Tmax was significantly decreased after pyeloplasty, we could not compare our preoperative and postoperative results because of insufficient data.

The role of APD in decision making regarding the performance of pyeloplasty in patients with UPJO has been evaluated in some previous studies. Mahmoud et al. (30) discovered that an initial APD measurement of 23 mm can effectively determine the need for surgery, boasting a specificity of 95% and sensitivity of 70%. In another study, Arora et al. (25) found that APD and pre-operative DRF were the only independent factors that predicted the need for surgery, whereas computer tomography and initial SFU grade of hydronephrosis were not. The analysis of the receiver operating curve indicated that an APD of 24.3 mm could predict the need for surgery, with a sensitivity of 73.1% and a specificity of 88.0%. Sharifian et al. (31) demonstrated that an APD of 15 mm could distinguish the surgical group with 95.2% sensitivity and 73.5% specificity. In another study, Wang et al. (32) demonstrated that both APD and renal parenchymal volume can predict the need for surgery, with an accuracy of 78.7%, sensitivity of 81.6%, and specificity of 77.6%. In our study, binary logistic regression analysis revealed that only increased renal pelvis APD was independently associated with pyeloplasty (p = 0.030; OR = 1.2). Furthermore, the optimal cut off value of the renal pelvis APD to predict pyeloplasty was 21.5 mm, with 84.0% sensitivity and 87.0% specificity.

This study has limitations. First, due to its retrospective nature, no comparison could be made with the postoperative period data. Second, since parenchymal thickness was not evaluated in patients, this parameter could not be included in the study.

Our findings suggest that both USG and dynamic renal scintigraphy are effective diagnostic methods for UPJO and surgical decisions. Renal pelvis APD at diagnosis detected on USG can be an easy and important parameter to follow-up the patient and make a reliable and immediate decision regarding surgery.

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