

Prediction of Clinical Outcomes in Prenatal Hydronephrosis: Importance of Gravity Assisted Drainage

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Purpose: In infants with SFU (Society for Fetal Urology) grade 3-4 congenital hydronephrosis, ^{99m}Tc -mercaptoacetyltriglycine diuretic renography assesses differential function and drainage half-time. We routinely also include the percent of radiotracer drained after 30 minutes of diuresis as well as after 15 minutes with the patient in the upright position. We investigated whether any 1 or more of these parameters on initial diuretic renography predicts persistent or worsening drainage parameters.

Materials and Methods: Infants 6 months or younger with grade 3-4 congenital hydronephrosis who presented between January 2009 and December 2014 were identified from billing data and included in analysis if they underwent at least 1 baseline diuretic renography. Those with structural anomalies were excluded. Baseline and followup, differential function, diuresis half-time, clearance at 30 minutes and clearance with the patient upright were abstracted and comparisons made between those with initially indeterminate diuresis half-time that underwent pyeloplasty vs. those showing spontaneous improvement.

Results: A total of 74 patients (82 renal units) with presumed ureteropelvic junction obstruction met inclusion/exclusion criteria. All 10 renal units with initial diuresis half-time less than 5 minutes resolved spontaneously and all 25 renal units with initial diuresis half-time greater than 75 minutes underwent pyeloplasty. Therefore, we defined the indeterminate group as the 47 renal units with initial half-time between 5 and 75 minutes. Of those 47 renal units with indeterminate initial diuresis half-time 23 (47%) underwent pyeloplasty and 25 (53%) resolved spontaneously. Indications for pyeloplasty included worsening in 17 cases, persistent obstruction in 4 and urinary tract infection in 1. Among renal units with indeterminate drainage clearance while upright and clearance at 30 minutes were the only variables that differed significantly between surgical cases and those that resolved spontaneously.

Conclusion: Radiotracer clearance with the patient upright and clearance at 30 minutes are more predictive of surgical management than diuresis half-time or differential function for renal units with indeterminate drainage. They should be included in the standard assessment of ureteropelvic junction obstruction.

Key Words: kidney, hydronephrosis, congenital, radioisotope renography, diuresis

Abbreviations and Acronyms

AUC = area under the curve	75
C30 = clearance at 30 minutes	76
CH = congenital hydronephrosis	77
CUP = clearance with patient upright	78
DR = diuretic renography	79
MAG-3 = ^{99m}Tc -mercaptoacetyltriglycine	80
rDF = differential renal function	81
ROC = receiver operating characteristic	82
RU = renal unit	83
$T_{1/2}$ = diuresis half-time	84
UPJ = ureteropelvic junction	85

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Most congenital hydronephrosis, which affects up to 4.5% of all pregnancies, is of low severity.¹ However, the few infants born with SFU grade 3-4 hydronephrosis routinely undergo postnatal testing, which includes sonography, contrast voiding cystography, and assessment of renal function and drainage by DR to identify those with or at risk for compromised renal function. Immediate surgical repair is rare with only 22% of infants undergoing pyeloplasty.²

Since most RUs with grade 3-4 CH have well preserved function despite impaired drainage, repeat testing by sonography and/or DR is indicated based on the criteria chosen by individual physicians. If 1 or more parameters change over time, which raises concern for renal function deterioration, many physicians recommend surgery. Few surgeons would dispute performing pyeloplasty when renal function deteriorates. However, no test predicts with certainty whether a particular drainage pattern will result in renal function loss. Additionally, to our knowledge there have been no studies demonstrating that a single DR performed during infancy predicts improvement or deterioration in drainage and function.

At our institution DRs are routinely processed to calculate rDF, post-diuresis drainage half-time and the percent of radiotracer drained (ie cleared) at 30 minutes. In addition, if C30 is less than 80% (20% or more residual), the percent of residual radiotracer that cleared after the patient was kept in the upright position for 15 minutes is calculated.

In this study we investigated which variables on initial DR might predict whether renal drainage and function are destined to improve or deteriorate on followup imaging.

MATERIALS AND METHODS

After institutional review board approval (CNMC No. 6497) we retrospectively reviewed the records of all infants who presented with grade 3 or 4 CH to the Division of Pediatric Urology at Children's National Health System between January 2009 and December 2014. Infants were identified by a query for division specific billing data using ICD-9 codes 753.29, 591 or 753.21 (congenital hydronephrosis, acquired hydronephrosis or congenital UPJ obstruction, respectively). In all cases a pediatric urologist in the division graded hydronephrosis according to the SFU grading system for postnatal hydronephrosis.³

Infants were included in analysis if they had grade 3 or 4 CH and at least 1 baseline DR available, and clinical decision making was complete. That is, pyeloplasty had been performed or obstruction had resolved spontaneously, as determined by improved drainage on DR or followup ultrasound demonstrating grade 2 or greater SFU hydronephrosis. In an effort to select cases of congenital UJP obstruction, exclusion criteria included age greater

than 6 months at the time of the first sonogram and structural anomalies, including hydroureter, ureterocele, solitary kidney or duplication.

All DRs were performed at our institution using a standardized technique similar to that previously described.⁴ After establishing a secured intravenous access and inserting an indwelling bladder catheter, MAG-3 was administered intravenously at a dose of 0.05 mCi/kg (minimum 1) and dynamic 15-second posterior images of the kidneys were obtained for 30 minutes. These pre-furosemide images were used for visual assessment of renal function and calculation of rDF.

Subsequently, furosemide (1 mg/kg, maximum 40 mg) was administered intravenously and dynamic 15-second posterior renal images were obtained for another 30 minutes. These post-furosemide images were used to assess the quality and pattern of clearance of radiotracer from the dilated collecting systems and calculate washout $T^{1/2}$ and C30. If C30 after furosemide with the patient supine was less than 80%, static 1-minute posterior renal images were obtained before and after the patient was kept upright for 15 minutes to assess gravity assisted drainage.

All studies were done with routine intravenous hydration using 5% dextrose in one-third normal saline at a dose of 15 ml/kg administered during 1-hour dynamic data acquisition. The studies were almost always done without sedation.

RUs were subdivided into 2 outcome groups, including those treated with pyeloplasty (surgical) and those that showed spontaneous improvement on subsequent imaging (nonsurgical). Indications for surgery in RUs undergoing observation were deterioration in post-diuresis drainage ($T^{1/2}$) and/or rDF on followup studies.

The Mann-Whitney test was used to determine differences in baseline DR, $T^{1/2}$, rDF, C30 and CUP between surgical and nonsurgical RUs. MedCalc, version 16.8.0 (<http://www.medcalc.org>) was used to calculate ROC curves by the methodology described by DeLong et al.⁵ The optimal criterion⁶ was used to determine the optimal cutoff point on the ROC curves.

RESULTS

A total of 1,784 patients younger than 6 months with a diagnosis of CH, acquired hydronephrosis or congenital UPJ obstruction presented to our pediatric urology office between January 2009 and December 2014. Of these patients 379 had at least 1 DR performed at our institution and 305 were excluded due to incomplete clinical data in 104, structural anomalies on imaging in 59, age greater than 6 months at the time of the first sonogram in 66, SFU grade hydronephrosis less than 3 at baseline in 66 or another reason in 10. Among the 74 eligible patients a total of 82 RUs were included in analysis. Mean \pm SD followup was 15.2 ± 14.1 months.

Of the 82 RUs available for review 47 went on to pyeloplasty and 35 showed spontaneous resolution on followup imaging and pyeloplasty was not done.

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