CLINICAL REPORT Guidance for the Clinician in Rendering Pediatric Care

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Perinatal Urinary Tract Dilation: Recommendations on Pre-/Postnatal Imaging, Prophylactic Antibiotics, and Follow-up: Clinical Report

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Perinatal urinary tract dilation (UTD) occurs in approximately 1% of all pregnancies and represents the second most common congenital anomaly detected prenatally, second only to cardiac defects. Causes of UTD include transient dilation, vesicoureteral reflux (VUR) and genitourinary obstruction. A vast majority of these conditions will never require surgical intervention. However, a subset of patients will be at increased risk of urologic and kidney disease. The purpose of this clinical report will be to review the current imaging modalities used for the evaluation of perinatal UTD and discuss the risk stratification for UTD, the indications for prophylactic antibiotics, and the use of lower tract imaging and renal scintigraphy (RS). Ultimately, the management of these children is individualized and should involve a shared-decision making process between the physician and parent/guardian that is evidence based.

The evaluation and management of more severe forms of bilateral UTD in boys who are at high risk for bladder outlet obstruction is outside of the scope of this document. Any concern for this entity should prompt an immediate consultation with a nephrology/urology specialist.

INTRODUCTION

The benefit of the detection of antenatal urinary tract dilation (UTD) continues to evolve as its natural history is better understood. In the 1980s, the properties of fetal ultrasonography (US) afforded the discovery of

abstract

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hydronephrosis in 1% to 3% of pregnancies, which led to a paradigm shift in the diagnosis of conditions such as ureteropelvic junction (UPJ) obstruction and vesicoureteral reflux (VUR). Early discovery of UTD prompted indiscriminate recommendations for prophylactic antibiotics, lower urinary tract imaging, and early surgical intervention in an effort to prevent urinary tract infections (UTIs) or deterioration in kidney function. These recommendations were made with good intentions but were not evidence based. Fortunately, most patients had good outcomes, which has afforded a more pragmatic approach over the last decade.

To this end, great effort has been made to work toward a model of care that maximizes the benefit of detection while minimizing evaluation and treatment that may not be evidenced based. Recent prospective registries have given insight into resolution rates for UTD, identified risk factors for UTI, and better informed the use of antibiotic prophylaxis.[1–4]

This report provides a framework for the pediatrician to better understand and educate parents on UTD in the context of recommendations for surveillance, use of prophylactic antibiotics, use of adjunct genitourinary imaging, and referral to a specialist. It is important to note that generally speaking, this report is aimed at patients with UTD and little to no concern for bladder outlet obstruction from various causes (eg, posterior urethral valves). Cases of bilateral UTD, especially those that are severe in nature and suggestive of bladder outlet obstruction, often associated with bilateral hydroureteronephrosis, bladder and urethral abnormalities, and/or oligohydramnios, are managed using a different paradigm both prenatally and postnatally.

ANTENATAL EVALUATION OF URINARY TRACT DILATION

Fetal Development and Detection of UTD Prenatally

Fetal genitourinary development begins early in the first trimester with urine production occurring around 14 weeks' gestational age, and it continues through the postnatal period.[5] The kidneys and bladder can reliably be detected on antenatal US by the end of the first trimester. US has a high sensitivity for UTD with large studies reporting sensitivities up to 91%.[6] The most severe abnormalities are likely to appear on the first screening US, which in the United States is recommended to be performed between 18 and 22 weeks of gestational age.[7,8] Pathology associated with UTD, thus, can have a significant impact on kidney development and ultimately function. Abnormalities detected on this screening US often prompt referral to a specialized practice able to perform a comprehensive US to confirm the abnormality as well as screen other organ systems.

Etiologies of UTD and Effect on the Kidney and Bladder

Diagnosing the precise etiology of UTD on antenatal imaging can be difficult. Causes of antenatal UTD are diverse and include transient/physiologic dilation, VUR, and any cause of obstructive uropathy (eg, ureteropelvic junction obstruction, posterior urethral valves, ureterocele, ectopic ureter, ureterovesical junction obstruction). The impact of UTD on the renal unit and the patient is also variable, ranging from no effect to increased risk of UTI, renal scarring, and dysplasia of the kidney.

Natural History of Antenatal Urinary Tract Dilation

Many cases of antenatal UTD are transient and spontaneously resolve. Two meta-analyses found spontaneous resolution rates of 64% to 75%.[9,10] More recent observational studies have equally found spontaneous resolution rates of 25% to 55%.[11,12]

Association Between Degree of UTD with Diagnosis and Outcome

Several studies have demonstrated that the less severe the antenatal UTD, the more likely it is to spontaneously resolve,[10–15] whereas the more severe the antenatal UTD, the more likely it was caused by an obstructive uropathy.[9,14,16,17] A meta-analysis by Lee et al found that the greater the degree of antenatal UTD, the greater the risk of specific pathologies including UPJ obstruction and posterior urethral valves.[9] In contrast, VUR is poorly correlated with degree of dilation.[9,18]

Although the number of patients with antenatal UTD who ultimately require postnatal surgery is quite low,[19] several studies show that the more severe the antenatal hydronephrosis, the more likely the patient will require surgical intervention.[11,12,15,17,20] One study found that patients whose UTD worsened between the second and third trimesters were more likely to require surgery.[21]

Goals of Antenatal Detection

The main benefit for detection prenatally is to afford the opportunity for consultation with pediatric specialists. Antenatal discussions should be framed around the differential diagnosis, indications for perinatal intervention; potential need for postnatal imaging, including renal and bladder ultrasonography (RBUS), voiding cystourethrogram (VCUG), and/or functional imaging; and recommendations for prophylactic antibiotics for those thought to be at increased risk of UTI. An algorithm is provided in the Supplemental Files to guide clinical decision making.

Historical Timing of Imaging

In the United States, women with low-risk pregnancies undergo 2 antenatal USs, and those with high-risk pregnancies will undergo more. Historically, when a diagnosis of

antenatal UTD is made, there has been lack of consensus regarding the frequency and timing of antenatal and postnatal follow-up imaging. A 2006 meta-analysis by Lee et al[9] found large variability among protocols. Recommendations ranged from vague (eg, "serially as needed") to specific (eg, "once at 32–34 weeks") and from infrequent (eg, "once in the third trimester") to numerous (eg, "once per month"). This guideline strives to delineate the ideal frequency and timing of follow-up based on current evidence.

Technique and Limitations of Antenatal Ultrasonography

Adherence to a standardized technique for antenatal US is recommended to allow accuracy and consistency across studies with a goal that future research might discover correlations between specific antenatal findings and underlying etiologies. **The measurement of the anteroposterior renal pelvis diameter (APD) prenatally should be performed with the fetal spine in the 6 o'clock or 12 o'clock position, and position should remain consistent from US to US.** Specific antenatal values (ie, all 7 UTD parameters) should be communicated to all postnatal providers, including the clinician performing the initial newborn examination and the primary care pediatrician, as these will guide management (Table 1). When feasible, images should be made available to the practitioner for review. Accuracy of antenatal US imaging is not only operator dependent but based on fetal positioning as well.[18] In most instances it should be used as a screening modality that sets the stage for in-depth postnatal evaluation to determine the exact etiology of UTD. Fetal MRI could be useful in certain cases when US fails, such as cases of anhydramnios or oligohydramnios. However, there is not sufficient evidence to support wide adoption, and access is not universal.

ULTRASONOGRAPHIC CLASSIFICATION SYSTEMS FOR ANTENATAL AND POSTNATAL URINARY TRACT DILATION

A diagnosis of antenatal UTD often necessitates postnatal imaging. Historically, several grading systems have been utilized with incomplete, heterogenous adoption[22] to classify and risk-stratify urinary tract dilation on US. A recent focus has been placed on use of a system that can be translated across time and specialties.

Anteroposterior Renal Pelvis Diameter

The measurement of APD has historically been the most commonly used system to measure urinary tract dilation on US. APD is an objective measurement of the renal pelvis at the mid-point of the kidney in the transverse plane. Normative values exist that account for gestational age. The established antenatal normal limits are APD less than 4 mm under 28 weeks and less than 7 mm after 28 weeks. The main advantage of this system is the objective nature of reporting. Disadvantages include that it is operator dependent and does not account for abnormalities of the rest of the collecting system, ureters or bladder. For obstructive lesions, the system demonstrates high specificity for severe dilation, and several studies have identified 15 mm of APD detected in the third trimester as a threshold predictive of UPJ obstruction.[17,23,24]

Society for Fetal Urology Grading System

The Society for Fetal Urology (SFU) grading system is a subjective assessment of kidney dilation and parenchymal integrity[25] (Figure 1). Currently, this is the most common system used postnatally.[26] The SFU system demonstrates high positive predictive value for both kidney function and need for surgical intervention in UPJ obstruction.

TABLE 1. Items Evaluated During Renal and Bladder Ultrasound

US Parameter	Measurement/ Findings	Notes
Anterior posterior renal pelvis diameter (APD)	(mm)	Measured on transverse image at max diameter of renal pelvis; measured with spine in 6 o'clock or 12 o'clock position Normal Ranges by Age • Prenatal <28 weeks: < 4 mm • Prenatal ≥28 weeks: < 7 mm • Postnatal: < 10 mm
Calyceal dilation Central (major calyces) Peripheral (minor calyces)	 Present/Absent Present/Absent	 Subjective assessment Subjective assessment
Parenchymal thickness	Normal/Abnormal	Subjective assessment
Parenchymal appearance	Normal/Abnormal	Evaluation of echogenicity, corticomedullary differentiation, and for cortical cysts
Ureter	Normal/Abnormal	Visualization is considered dilated and abnormal, though intermittent visualization of the ureter is considered normal postnatally.
Bladder	Normal/Abnormal	Evaluation of bladder wall thickness, presence of ureterocele, dilated posterior urethra
Unexplained oligohydramnios	Present/Absent	

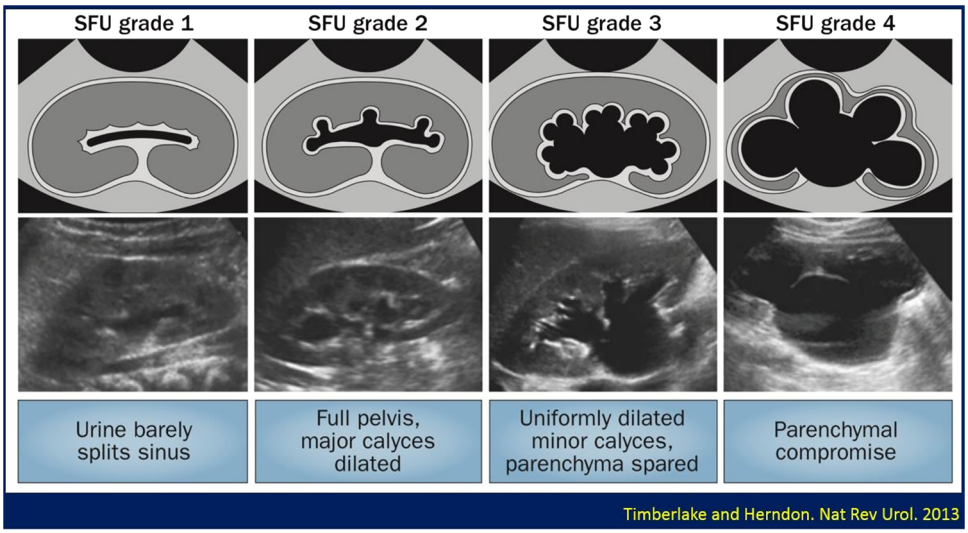


FIGURE 1.
Society for Fetal Urology Grading System.

The advantages are its ease of learning and application. Disadvantages include its limited adoption by other specialists outside of pediatric urology, its subjective nature, as well as the lack of inclusion of the entire collecting system including the ureters and bladder during assessment.

Urinary Tract Dilation (UTD) Grading System

In 2014, a multidisciplinary consensus meeting including representatives from 8 professional societies involved in the diagnosis and management of UTD was held to unify the grading systems and establish a common language among practitioners.[18] The goals were to develop a standard process for imaging and reporting of US results both antenatally and postnatally. Additionally, postnatal normative values that represented physiologic dilation (APD < 10 mm) were agreed upon to curtail low-yield testing and interventions. The term UTD was chosen to describe all degrees of antenatal and postnatal dilation, as opposed to the terms *hydronephrosis, pelviectasis, caliectasis,* and *pelvicaliectasis.* The UTD system is a combination of both the objective and subjective characteristics of the APD and SFU systems and measures variables that include: APD, central calyceal dilation, peripheral calyceal dilation, appearance and thickness of kidney parenchyma, appearance of ureters, appearance of bladder, and unexplained oligohydramnios (Table 1).

ANTENATAL RISK STRATIFICATION/MANAGEMENT

Thresholds for antenatal diagnosis of UTD are based on gestational age at the time of imaging, whether less than or greater than 28 weeks gestation (Figure 2). For both age groups, fetuses are classified into a low-risk group (UTD A1 [denoted A for antenatal]) or an increased risk group (UTD A2-3). In addition to the common parameters between antenatal and postnatal systems, the antenatal system also considers presence or absence of unexplained oligohydramnios. Unlike the postnatal classification, the intermediate and high-risk groups are combined in the antenatal system. This difference relates to the difficulty in accurately differentiating central vs peripheral calyceal dilation in the antenatal US. In both the antenatal and postnatal risk classifications, the most concerning abnormal finding is used to place the patient into a higher risk category (ie, if there is ureteral dilation but the APD is less than 10 mm at greater than 28 weeks gestation, the fetus is still considered UTD A2-3).

The antenatal recommendations are based on the timing of the US and severity of UTD. If UTD is low-risk prior to 28 weeks, then only one US is recommended after 32 weeks' gestation. On the other hand, if the UTD is intermediate/high-risk, then serial US every 4 weeks is recommended. The need/timing for specialty consultation with urology and/or nephrology equally varies by severity of disease (Figure 3).

POSTNATAL EVALUATION OF UTD

Multiple imaging modalities are commonly used to better classify UTD and diagnose its exact cause postnatally. These tests and their uses, as well as risks and benefits are described in Table 2.

Renal and Bladder Ultrasonography

RBUS is the initial imaging study of choice to evaluate children with perinatal UTD. The postnatal degree of dilation of the pelvicalyceal system and ureters helps guide additional

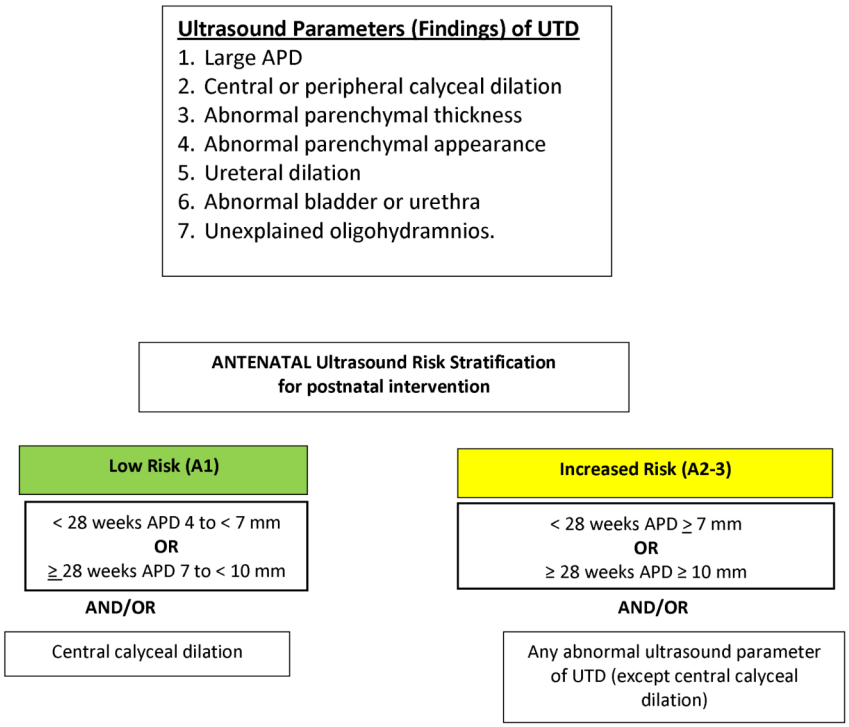


FIGURE 2.
*Prenatal ultrasound risk stratification. **Stratification is based upon the most concerning ultrasound finding**. For example, a fetus with an anterior-posterior renal pelvis diameter (APD) within the UTD A1 range but with peripheral calyceal dilation would be classified as UTD A2-3.

	Follow-Up Ultrasound	Urology/Nephrology Consultation
Low Risk (A1)	Repeat once prenatally at ≥ 32 weeks	Not indicated prenatally
Increased Risk (A2-3)	Repeat every 4 weeks until delivery	Consider prenatal consult

FIGURE 3.
Suggested PRENATAL Management Based Upon US < 32 weeks.

investigations and interventions.[18,27] RBUS advantages include that it is noninvasive, is widely available, is quickly performed, lacks ionizing radiation, and is less costly than other imaging modalities.[28] Additionally, RBUS does not require specific patient positioning, infants can be imaged supine, prone, or while being held in the upright position. However, scanning newborns and infants in the prone position may overestimate the degree of dilation in up to 10% of patients, and this consideration should be taken into account especially in the first postnatal study.[29] For optimal assessment of UTD, RBUS should be performed after 48 hours of life, as studies during the first 48 hours of life might underestimate the degree of dilation due to physiologic neonatal third spacing, which does not fully resolve until day 7 to 10.[30–34]

Adherence to standard technique for postnatal US and reporting of results is paramount to maintain consistency (see Table 1). The first postnatal US serves as a determinant of risk because, in general, higher levels of dilation correspond with higher need for surgery.[20,35,36]

TABLE 2. Risks and Benefits for Postnatal Radiologic Imaging

Features / Imaging Modality	Anatomy versus Function	Anatomy Assessed				Duration (min)	Prep S/H/UC	Ionizing radiation (Yes/No)	Nephrotoxic (Yes/No)	Relative cost
		Kidneys	Bladder	Ureters	Urethra					
Ultrasound	Anatomy	Yes	Yes	Only if abnormal	Yes	30	None	No	No	$
VCUG	Anatomy	Collecting systems (if reflux)	Yes	Yes (if reflux)	Yes	30	UC	Yes	No	$$
ceVUS	Anatomy	Collecting systems (if reflux)	Yes	Yes (if dilated or reflux)	Yes	30	UC	No	No	$$
MAG 3 diuretic renography	Function	Renal function	No	No	No	90	H/UC	Yes	No	$$$
MR Urography	Anatomy & Function	Anatomy & function	Yes	Yes	Yes	60	S/H/UC	No	No**	$$$$

S/H/UC: Refers to the need of sedation (S), intravenous hydration (H) and urinary catheter (UC) placement for the completion of the study. In general, sedation for any of these imaging tests is only needed in patients older than 6 months and under 5 years of age.

**Gadolinium-based contrast agents used for MR Urography have a small risk of adverse allergy-like reactions and linked to nephrogenic systemic fibrosis (NSF) a rare disease reported in patients that receive gadolinium and have end-stage renal disease.

Voiding Cystourethrography

Fluoroscopic VCUG is the gold standard for diagnosing and grading VUR,[37,38] which occurs in 15% of children with prenatally diagnosed isolated UTD.[39–41] It can also yield information about bladder or urethral abnormalities contributing to UTD. The standards for technique, image acquisition and interpretation have been previously reported by the American Academy of Pediatrics in a joint publication from the sections of urology and radiology.[38] In terms of technique, a VCUG study consists of instilling iodinated contrast material into the bladder via a urinary catheter and imaging with pulsed fluoroscopy. The key images include the bladder at different levels of filling, the urethra during voiding, and the renal fossae immediately after voiding, to document the presence and grade of reflux.[37,38] Imaging during multiple filling cycles of the bladder is helpful in infants who void at low volumes.[37]

A normal postnatal US does not exclude reflux.[42] The risk of VUR in patients with a nondilated or a mildly dilated collecting system may be as high as 25%.[43] Fortunately, VUR associated with prenatally detected UTD has a high incidence of spontaneous resolution.[42,44] Historically, some authors recommended VCUG in all children with prenatally detected UTD, and there was great practice variability.[45] Between 26% and 57% of pediatric urologists will recommend VCUG and antibiotics for patients with UTD P2, and between 85% and 88% will recommend them for patients with UTD P3.[46] Currently, it is largely accepted that UTD in itself should not be considered an indication for VCUG in asymptomatic neonates and infants, and its optimal use is an area of ongoing research.[19]

Contrast-Enhanced Voiding Urosonography

In addition to VCUG, similar information can be extracted from contrast-enhanced voiding urosonography (ceVUS).[47,48] CeVUS has shown to be more sensitive in detecting VUR than VCUG, with a higher grade of reflux in a majority of patients.[49,50] CeVUS is not uniformly available at most institutions, which limits its application.

If ceVUS is chosen as an alternative to VCUG, US instead of fluoroscopy is used for imaging and the iodinated contrast instilled into the bladder is substituted by a US contrast agent (ie, microbubbles). While the images of the kidneys and bladder are acquired in a similar fashion as a regular RBUS, images of the urethra during voiding are necessary and usually obtained via a suprapubic and/or transperineal approach.

Functional Renal Imaging - Renal Scintigraphy

Functional nuclear medicine renal imaging, known under several names including renal scintigraphy (RS), diuretic renography, furosemide renography, radionuclide RS, radioisotope renography, and nuclear medicine renogram, follow the uptake of radiotracers by the kidneys and their excretion through the collecting system. RS imaging captures gamma rays emitted by the patient after intravenous radiotracer administration and follow the biodistribution of radiotracer throughout the body. The most commonly used radiotracer in the evaluation of UTD is ^{99m}Tc-MAG3 (technetium-99m-labeled-mercaptoacetyl triglycine), which reaches the collecting system via tubular secretion[51–54] and offers better overall quality of the images, even in patients with a low glomerular filtration rate, edema, or ascites.[55] Several other radiotracers can be used to calculate kidney function as well, including ^{99m}Tc-DMSA (technetium-99m-labeled-dimercaptosuccinic acid) and ^{99m}Tc-DTPA (technetium-99m-labeled-diethylenetriamine penta-acetic acid). ^{99m}Tc-DMSA undergoes cortical tubular binding while ^{99m}Tc-DTPA measures glomerular filtration.[51–54]

The RS (^{99m}Tc-MAG3) technique requires a well-hydrated patient using intravenous or oral hydration protocols. Before beginning the study, a urinary catheter is placed to create an unobstructed outlet system to reduce the potential negative effect of a distended bladder on radiotracer excretion and the confounding effect from possible high-grade vesicoureteral reflux. With RS, there is concern about the use of radiation. However, the effective radiation dose is low, and more than 95% of the radiotracer is cleared within 3 hours in patients with normal kidney function,[51,56,57] which allows the child to safely go to clinic or home after the study is performed.

In cases of UTD, RS is used to establish a baseline differential kidney function, which indicates the relative contribution of each kidney to the overall kidney function (warranting intervention if functional decline is documented) and to differentiate between dilated collecting systems *with* or *without* obstruction. RS ^{99m}Tc-MAG3 measures 2 important parameters. First, the parenchymal uptake (first pass from the circulation into the kidney), which reflects the split renal function (or differential renal function). Second, clearance is evaluated over 30 minutes to determine the presence and level of obstruction of the collecting system from the UPJ to the ureterovesical junction.[53,54] If there is retained radiotracer in the collecting system after 15 or 20 minutes, a diuretic (furosemide, 1.0 mg/kg; maximum dose of 40 mg) is administered to differentiate dilated systems *with* from those *without* a critical obstruction.[58] A dilated but unobstructed system will respond to diuretics, while a truly obstructed system will retain radiotracer as it is unable to increase the rate of clearance through the critically narrowed segment. This is crucial because only obstructed systems require (and benefit from) surgery. Note that after surgical intervention, a previously dilated and capacious system may not regress back to normal and does not indicate failure of surgery. In normal subjects, ^{99m}Tc-MAG3 split renal function values ranges from 42% to 58%,[58] and thus a threshold of 40% split function is used to identify those in which the obstruction is felt to be compromising kidney function.

Accurate RS results in infants with UTD rely on adequate renal blood flow and kidney development; thus, tests should ideally be deferred until at least 6 to 12 weeks of age. During the first months of life, kidney immaturity results in low uptake of ^{99m}Tc-MAG3 and slower cortical transit times. While there is evidence that RS can be performed at any age, and the decision of timing is based on the specific clinical indication, practitioners often delay for up to 6 to 12 weeks.[59–62] Studies performed before 6 to 12 weeks may over- or underestimate the kidney function and are not generally predictive of outcome.[63,64]

Functional Magnetic Resonance Urography

Magnetic resonance urography (MRU) is a reliable and safe diagnostic tool that can substitute RS for the determination of differential kidney function and provide detailed information about the morphology of the kidney with a dilated collecting system.[65] MRU provides morphologic characterization of the kidney parenchyma and the entire urinary tract, which can be advantageous in the diagnostic and/or presurgical work up of neonatal UTD.[66,67] Similar to RS, MRU aims to differentiate between capacious and obstructed systems, determine the level of the obstruction, and estimate the relative contribution of each kidney to the overall kidney function. Despite advantages related to providing high-quality anatomical and functional data in a single examination that lacks radiation, MRU has ancillary disadvantages including need for sedation or anesthesia for the younger children, higher cost, and relatively limited availability.[28]

As part of the protocol and similar to RS, patients receive hydration and diuretics (furosemide), but hydration is given intravenously and the furosemide is administered prior to image acquisition for better resolution. During the dynamic scan, the enhancement of the aorta, the kidneys, and in most cases the initial drainage flow of the urinary system are obtained and used to calculate quantitative parameters as well as enhancement and excretion curves.[68] The enhancement and excretion curves are a display of the change of signal intensity over time and calculated for the aorta, renal parenchyma, pelvis, and calyces with higher spatial resolution than nuclear medicine studies. The important clinical functional information obtained from analyzing contrast flow dynamics allows differentiation of obstructed from nonobstructed renal collecting systems.[69]

POSTNATAL UTD RISK STRATIFICATION

Under the current UTD classification (Figures 4a, 4b), patients are stratified into 3 tiers postnatally based on their RBUS: low (UTD P1), intermediate (UTD P2), and high (UTD P3) risk.[18] The risk classification helps clinicians decide the need for investigations such as lower urinary tract imaging (eg, VCUG or ceVUS) or functional imaging.

POSTNATAL MANAGEMENT OF UTD

Over the last 2 decades, there has been a focus of research on analysis of outcomes in patients with UTD to better inform providers as to which patients truly benefit from additional evaluation and treatment for UTD. This research has informed creation of both antenatal and postnatal recommendations for patients with UTD regarding US surveillance, subspecialist referral, need for additional imaging studies and need for antibiotic prophylaxis, although there is lack of consensus on some of these topics (Figures 5 and 6).

Consideration of UTI, Renal Scarring, and Antibiotic Prophylaxis in the Management of UTD

Diagnosis and treatment of UTI is outside of the scope of this report. UTIs in this report refer to febrile UTI and, thus, are presumed to be pyelonephritis. Imaging confirmation of pyelonephritis is not always available or necessary for management.

Emerging research has endeavored to determine the frequency of UTI and renal scarring in patients with UTD, the timing of UTI if it does occur, whether certain subpopulations are at higher risk than others for UTI and renal scarring, and whether prophylactic antibiotics decrease any of these risks. This report summarizes the current evidence, acknowledging this is a dynamic area of active research subject to change.

Risk of UTI in Children with UTD and Which Subpopulations Are at Increased Risk

Estimates of UTI rates in patients with prenatally diagnosed UTD range from 8% to 22% with a linear relationship between the degree of dilation and the development of a UTI.[9] Most recently, data from the SFU multicenter prospective hydronephrosis registry evaluated 801 patients over a 12-year interval enrolled prospectively from 2008–2020.[70] In patients with isolated hydronephrosis, the overall UTI rate was 4.2%. When stratified, the UTI rate in patients with high-grade hydronephrosis was 6.0% compared with 3.2% in those with low-grade hydronephrosis. Another report from the same registry identified ureteral dilation ≥7 mm as a significant risk factor for UTI in over 200 patients.[71] These findings are consistent with numerous prior studies, which have demonstrated higher rates of UTI in patients with *high-grade* UTD[3,4,72–78] and/or hydroureteronephrosis.[3,72,76,78,79] In addition to these 2 findings, other risk factors that have been shown to increase risk of UTI in patients with UTD include: female gender,[1,3,15,73,75,80–82] intact foreskin,[1,3,19,72,73,75] and obstructive uropathy[78] (Table 3a). Studies that assessed whether or not patients with both UTD and VUR are at increased risk for UTI (compared to UTD in the absence of VUR) show conflicting results.[1,3,15,72–75,77] Of note, most of the mentioned studies excluded patients with known uropathy at birth (eg, solitary kidney). These frequently excluded patient populations are listed within Table 3b and should also be considered at increased risk.

Knowledge of timing will also affect the clinician and family's management decisions. The incidence of UTI prior to the first postnatal ultrasound is low (1.4%).[83] Regarding longer term data, Zee et al reported prospective data from the multicenter SFU registry on 213 patients with antenatal UTD, showing that 89% of UTIs in this cohort occurred before the first year of life.[4]

UTI and Renal Scarring

The goal of preventing UTIs is to prevent their short-term sequelae, such as bacteremia, and long-term sequelae, such as renal scarring, hypertension, chronic kidney disease, and kidney failure. A more recent study, in which Shaikh et al combined data from the RIVUR and CUTIE studies, found similar results: higher rates of renal scarring in patients with more frequent UTIs. Compared with patients with a history of one UTI, having 2 UTIs increased the odds of renal scarring by a factor of 12 and having 3 UTIs by a factor of 14.[84] The odds of renal scarring were also higher in patients who were toilet-trained or had hydronephrosis, high-grade VUR, or ureteral duplication.[85]

Effectiveness of Continuous Antibiotic Prophylaxis in Children with UTD

Historically, patients with antenatal UTD were empirically prescribed continuous antibiotic prophylaxis to prevent UTI and, ultimately, kidney damage. To date, no studies have addressed the effect of continuous antibiotic prophylaxis (CAP) on renal scarring in patients with UTD. Multiple studies, including some meta-analyses, have assessed the benefits of CAP to prevent scarring in other patient populations (such as VUR). None found a reduction in renal scarring, although they were not powered appropriately to answer this clinical question.[85–93]

Moreover, in recent years, conflicting studies/reports have questioned the efficacy of CAP in patients with UTD, especially in patients with low-risk UTD. A recent 2017 meta-analysis by Easterbrook et al found no significant difference in UTI rates between patients that were (9.9%) or were not (7.5%) given CAP.[73] An older meta-analysis by Braga et al found that CAP prevented UTIs in patients with *high-grade* UTD (NNT = 7) but made no difference in patients with *low-grade* UTD.[74] Notably,

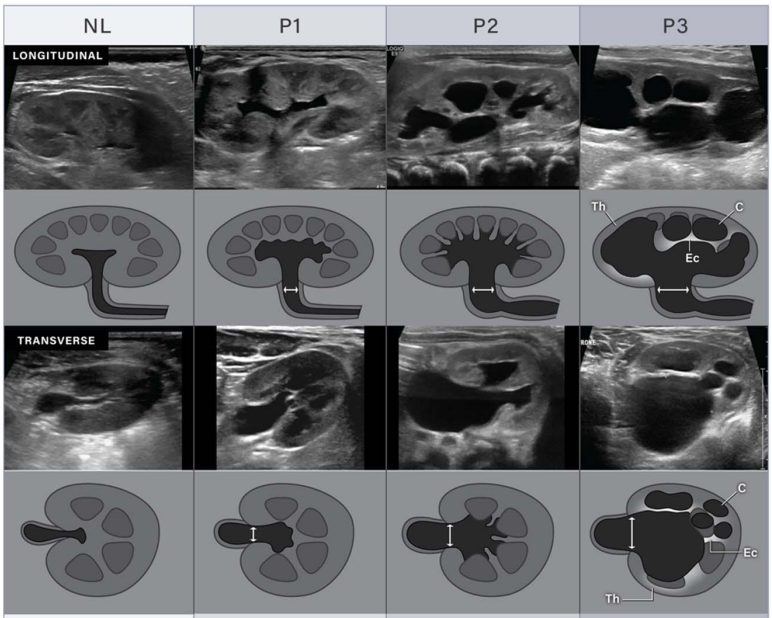
POSTNATAL Ultrasound Risk Stratification
Based upon imaging obtained >48 hours after birth

Low Risk (P1)	Intermediate Risk (P2)	High Risk (P3)
APD 10 to <15 mm **AND/OR** Central calyceal dilation	At least ONE of the following (but nothing in the high-risk list): APD ≥15 mm Peripheral calyceal dilation Ureteral dilation	Findings in P2 AND Any ONE of the following: Abnormal parenchymal thickness Abnormal parenchymal appearance Abnormal bladder Abnormal urethra

Ultrasound Parameters (findings) of UTD

1. Central or peripheral calyceal dilation
2. Abnormal parenchymal thickness
3. Abnormal parenchymal appearance
4. Ureteral dilation
5. Abnormal bladder or urethra

(A)



NORMAL FINDINGS	P1 FINDINGS	P2 FINDINGS		P3 FINDINGS
AP renal pelvic diameter **<10 mm**	AP renal pelvic diameter **10-15 mm**	AP renal pelvic diameter **>15 mm**		AP renal pelvic diameter: **>15 mm**
Calyceal dilation **None**	Calyceal dilation **Central**	Calyceal dilation **Central & peripheral**		Calyceal dilation: **Central & peripheral**
Parenchyma: **Normal**	Parenchyma: **Normal**	Parenchyma: **Normal**		Parenchyma: **Abnormal** (Thinning, echogenic, or cysts)
Ureters, bladder, urethra: **Normal**	Ureters, bladder, urethra: **Normal**	Ureters: **Abnormal**	Bladder, urethra: **Normal**	Ureters, bladder, urethra: **Abnormal**

(B)

FIGURE 4.
(A) Postnatal ultrasound risk stratification. **Stratification is based upon the most concerning ultrasound finding**. For example, if the anterior-posterior renal pelvis diameter (APD) is in the UTD P1 range, but there is peripheral calyceal dilation, the classification is UTD P2. Similarly, the presence of parenchymal abnormalities denotes UTD P3 classification, regardless of APD measurement. (B) Postnatal Urinary Tract Dilation Grading System.

UTD Classification	Definition	Initial Postnatal US	Urology/Nephrology Consultation
Incomplete or Unclear Classification		Follow postnatal evaluation similar to UTD A1	Follow postnatal evaluation similar to UTD A1
Resolved at Last Prenatal Ultrasound		If prior US were all A1 --> No postnatal evaluation or surveillance required	
		If any prior US was A2-3 --> Manage according to recommendations for "Increased Risk (A2-3)" below.	
Low Risk (A1)	≥ 28 weeks APD 7 to <10 mm **AND/OR** central calyceal dilation	≥48 hrs to 6 weeks of age Need not delay discharge*	May consider with outpatient follow-up
Increased Risk (A2-3)	≥ 28 weeks APD ≥10 mm **OR** any abnormal parameter (except central calyceal dilation)	Prior to discharge. Ideally after 48 hr of life.	Recommended prior to discharge

The ultrasound should be prioritized and can either be ordered prior to discharge or at the first primary care visit to allow for imaging within 4-6 weeks of life.

FIGURE 5.
Suggested Subsequent POSTNATAL Management Based Upon Antenatal Ultrasound.

UTD Classification	Definition/Circumstance	Follow-Up Ultrasound (2nd Postnatal Ultrasound)	Antibiotic Prophylaxis	VCUG/ceVUS	MAG3/fMRU	Urology/Nephrology Consultation
Resolved		3-9 month of age	Not recommended	Not recommended	Not recommended	Not recommended
Low Risk (P1)	APD 10 to <15 mm **AND/OR** central calyceal dilation	3-6 months of age	Not recommended	Not recommended	Not recommended	Outpatient
Intermediate Risk (P2)	APD ≥15 mm **AND/OR** peripheral calyceal dilation	1-3 months of age	Use shared decision making to determine use	Use shared decision making to determine need	Use shared decision making to obtain at >6 weeks of age	Inpatient consult or expedited outpatient referral
	Ureteral dilation ≥7 mm	1-3 months of age	Recommended	Recommended within 1-3 months of age	Use shared decision making to obtain at >6 weeks of age	Inpatient consult or expedited outpatient referral
High Risk (P3)	Findings in P2 **AND** abnormal parenchymal thickness **or** appearance **or** abnormal bladder	1 month of age	Recommended	Recommended within 1-3 months of age	Recommended at >6 weeks of age.	Inpatient consult or expedited outpatient referral

fMRU indicates functional magnetic resonance urography.

FIGURE 6.
Suggested Subsequent POSTNATAL Management Based Upon Initial Postnatal Ultrasound. fMRU indicates functional magnetic resonance urography. Most studies evaluating risk factors for UTI with UTD and/or VUR have excluded known uropathies. It is recommended that children with these diagnoses be considered high risk, as most are associated with obstructive uropathy or VUR.

TABLE 3A. Children With UTD AND Risk Factors for UTI
Female gender
Intact foreskin (UTD P2/P3)
UTD P3
Distal ureteral dilation ≥7mm
Vesicoureteral reflux
Obstructive uropathy (suggested by bilateral UTD)

TABLE 3B. Children With Known Uropathy at Birth
Ureteropelvic Junction Obstruction
Posterior Urethral Valves
Ectopic ureter
Duplex ureter
Solitary kidney
Multi-cystic dysplastic kidney
Bladder diverticulum
Neurogenic bladder
Bladder exstrophy
Spina bifida
Horseshoe kidney
Crossed-fused ectopia
Cloacal exstrophy

neither meta-analysis included any RCTs. A recent 2021 study by Holzman et al also found that CAP prevented UTIs in patients with *high-risk* UTD with concomitant ureteral dilation ≥7 mm and VUR.[71] However, data from the same year from the SFU Hydronephrosis Registry demonstrated no benefit for CAP for isolated UPJ-like hydronephrosis, even when they adjusted for grade of UTD or other risk factors (eg, female gender).[70] Four systematic reviews and 2 recent observational studies also document conflicting results.[72,80,81,83,94,95]

Some studies have shown circumcision to be an equally preventive alternative to antibiotic prophylaxis for prevention of UTI in boys with UTD. As previously mentioned, most UTIs occur within the first year of life, and rates beyond that age are low. Clinicians should therefore consider stopping antibiotic prophylaxis at 12 months of age, unless the child has VUR or ureteral dilation ≥7 mm.

Numerous studies have evaluated bacterial resistance in children on CAP with diagnoses other than UTD, such as VUR. Two meta-analyses calculated that CAP increased the odds of multidrug-resistant infection by 6.5 to 9 times.[86,96] A Cochrane review found similar, although not statistically significant, results.[97] There is also growing interest in the question of how CAP affects the microbiome.

Amoxicillin is the primary antibiotic prescribed for UTI prophylaxis in the newborn in the United States. It covers some gram-negative rods and *Enterococcus* species. After 2 months of life, the most commonly prescribed antibiotic for prophylaxis is trimethoprim-sulfamethoxazole, which attains high concentrations in the urine and results in less bacterial resistance. Before 2 months' corrected gestational age, trimethoprim-sulfamethoxazole can cause bilirubin displacement leading to kernicterus. Nitrofurantoin is an equally effective prophylaxis and is excreted primarily in the urine and has poor tissue penetration thus decreasing impact on the gut microbiome. If a cephalosporin is chosen, the clinician should strongly consider using a first-generation cephalosporin as bacterial resistance remains low.[98] Local patterns of resistance should be considered using the hospital antibiogram or other sources of community antibiotic sensitivity information.

A shared decision-making model that includes the benefits and risks of CAP should be discussed with the family prior to implementation of therapy. In general, the higher degree of suspicion for obstructive UTD, the more CAP benefits the patient and outweighs the inherent risk of developing an infection with a multidrug-resistant organism.

POSTNATAL DIAGNOSIS OF THE COMMON ETIOLOGIES OF UTD AND NEED FOR ADJUNCT IMAGING

Specific diagnosis of the cause of UTD is made most often postnatally, whether through RBUS alone or with the aid of the aforementioned adjunct imaging studies. The most common causes of prenatally diagnosed UTD are transient/physiologic dilation, UPJ obstruction, and vesicoureteral reflux (Table 4).

TRANSIENT UTD

Transient dilation of the urinary tract is the most common etiology of UTD. Two recent reports from large prospective registries affirm that 90% to 100% of patients with P1 will resolve by 4 years of age.[1,2]

UPJ Obstruction

A majority of patients with UPJ-like UTD will not need surgical correction and can be observed with serial imaging.[81,99] Several studies have reported that the antenatal APD threshold may be predictive of the need for surgery for UPJ obstruction.[17,23,100] More recently, a review of more than 1000 patients identified an APD cutoff of 15 mm to be predictive of the need for intervention and confirmed that postnatal measurements were superior to antenatal

TABLE 4. Causes of Urinary Tract Dilation	
Non-Obstructive	**Obstructive Uropathies**
-Transient/physiologic dilation - VUR	Ureteral Obstruction: - ureteropelvic junction (UPJ) obstruction - Ureterocele - Ectopic ureter - Obstructing megaureter Urethral Obstruction: - Posterior urethral valves - Urethral atresia - Other

measurements.[36] Those patients at increased risk can be evaluated with renal functional imaging. However, practice varies and some advocate for the use of serial US.[46,99,101,102]

Vesicoureteral Reflux

Understanding of vesicoureteral reflux and its effects on kidney function have significantly evolved over the last decade. Screening for VUR has traditionally been recommended in patients with prenatally diagnosed UTD, because VUR has been reported in up to 31% of patients with antenatal UTD.[9,103–105] Antenatal UTD correlates poorly with severity of VUR, however.[9] The utility of screening patients for VUR based on UTD has been challenged, as the clinical relevance of reflux in the absence of UTI with normal bladder function is unclear. Two distinct types of patients have been identified who present with VUR. The most common scenario is the child (usually female) with recurrent febrile urinary tract infections. These children usually have less renal scarring and lower grades of VUR. The less common scenario is the child with high grade VUR commonly detected through antenatal screening with significant renal dysplasia ("reflux nephropathy") without UTI.[103] These latter children have high rates of resolution of VUR and low rates of UTI, especially in the circumcised state, suggesting that screening for VUR may not be beneficial based on antenatal UTD alone, in the absence of UTI.

Until further prospective studies can better determine the value of identifying VUR in patients that present with UTD prenatally, a shared decision-making model should be used with families to discuss the benefit of a VCUG/ceVUS. Risk factors such as gender, circumcision status, and/or ureteral dilation should be offset with the benefit of prophylactic antibiotics at mitigating UTI and/or renal scarring.

CONSIDERATIONS FOR SEVERE BILATERAL URINARY TRACT DILATION/SOLITARY FUNCTIONING KIDNEY WITH URINARY TRACT DILATION

The preceding recommendations in this report are not primarily aimed at cases of severe bilateral UTD. Patients with severe bilateral UTD with dilated ureters, abnormal bladder morphology, and oligohydramnios should be evaluated for underlying causes of bladder outlet obstruction, which include posterior urethral valves, urethral atresia, prune belly syndrome, pelvic masses, and spinal dysraphism. If bladder outlet obstruction is suspected prenatally, parents should receive appropriate counseling regarding differential diagnoses, possible effects on bladder and kidney function, and possible postnatal evaluation and management strategies.

Postnatally, infants with suspected bladder outlet obstruction should undergo prompt urology and nephrology consultation, bladder decompression, appropriate imaging, and initiation of antibiotic prophylaxis, ideally all within 48 hours of life. Assessment of overall kidney function with serum testing is also necessary, but it should be remembered that serum creatinine in the neonate will reflect maternal creatinine in the first few days of life.

KEY RECOMMENDATIONS

1. It is important that newborns with UTD receive needed care after discharge. This may include follow-up imaging and subspecialist follow up. It is important that a care plan is developed among treating clinicians and is implemented through coordination between all members of the care team. Communication and definition of roles among all providers and the patients/families/caregivers are needed to clearly delineate responsibility for follow-up related to UTI risk and diagnosis, ordering and reviewing results, providing follow-up care, and communicating the follow-up care plan with the family. Each family's social and economic needs for follow-up care should be assessed with necessary support arranged prior to discharge to reduce barriers to care.
2. Urinary tract dilation should be classified according to the Urinary Tract Dilation Grading System for antenatal (A1-3) and postnatal (P1-3) scoring.
3. **The measurement of the anteroposterior renal pelvis diameter (APD) on antenatal US should be performed with the fetal spine in the 6 o'clock or 12 o'clock position, and position should remain consistent from US to US.**[18]
4. **For gestations identified as *low-risk* (UTD A1) diagnosed prior to 32 weeks, a repeat antenatal US should be obtained at ≥32 weeks**[18] **to assess for improvement or progression through pregnancy.** Antenatal UTD may improve, remain stable, or progress throughout pregnancy. Resolution in the antenatal period has been shown to occur in approximately 80% of cases when the APD is between 4 and 8 mm during the second trimester.[106–108] Persistent UTD of any severity should prompt postnatal evaluation.
5. **For gestations identified as *low-risk* (UTD A1) that resolve on US after 32 weeks, no postnatal evaluation or surveillance is required.** While some patients with prenatally resolved UTD will have postnatal UTD, these patients are at very low risk for UTI, kidney function deterioration, or need for surgical intervention.[109] Patients with presumed mild or resolved but incomplete or unclear antenatal classification should undergo postnatal evaluation similar to UTD A1.
6. **For gestations identified as *low-risk* (UTD A1) that persists after 32 weeks, postnatal evaluation should include RBUS between 48 hours of life and 6 weeks of life.** It is important that the US be

deferred to after 48 hours to account for intravascular volume depletion that occurs in the fetus after delivery. This form of third spacing redistributes over the first 24 to 48 hours of life and can cause US performed during that period to underestimate UTD.[110] Discharge from birth hospitalization does not need to be prolonged for these *low-risk* infants if clinically stable. The US should be prioritized and can be ordered either prior to discharge or at the first primary care visit to allow for imaging within 4 to 6 weeks of life.

Certain clinical situations may require postnatal US to be performed sooner than 48 hours. With suspected bladder outlet obstruction (eg, posterior urethral valves), urgent intervention may be needed for urinary tract decompression.

7. **For gestations identified as *increased-risk* (UTD A2-3) diagnosed at any time during pregnancy, repeat antenatal US should be obtained every 4 weeks thereafter prior to delivery for reassessment.** Repeat assessment is recommended given possible progression of UTD and implications on management plan and location of delivery (local vs tertiary care center).
8. **For newborns that were identified as *increased-risk* (UTD A2-3) at any time during pregnancy, an RBUS should be obtained during the birth hospitalization to facilitate possible need for antibiotic prophylaxis and to determine need for further imaging. Ideally, this US should be performed after 48 hours of life.** Birth hospitalization need not be prolonged to obtain this first US unless there is suspicion for bladder outlet obstruction.
9. **For gestations identified as *increased-risk* (UTD A2-3), antenatal consultation with nephrology and/or urology should be obtained.** One significant benefit of antenatal detection of urologic abnormalities is antenatal counseling for families. Especially in instances in which urgent or invasive surgical intervention may be warranted postnatally or in which significant compromise of kidney function is anticipated, a discussion before birth can allow time for families to adequately process information and plan for postnatal care. In-person or telemedicine consultation in conjunction with antenatal providers can allow all caregivers for both mother and baby to develop an organized plan of care for the postnatal period. Generally speaking, conditions that most benefit from antenatal multidisciplinary consultation include patients in the UTD A2-3 risk group and any patient with bilateral UTD. Indications for fetal intervention for UTD are outside of the scope of this report. However, intervention for bladder outlet obstruction is offered at some centers, and a candid discussion regarding known risks and benefits with families may be appropriate in some cases.
10. **Orientation and patient position on postnatal US should be documented.** The APD should be calculated at the midpoint of the kidney in the transverse plane (corresponding to the region of the hilar vessels). The maximal diameter should be obtained within the confines of the renal cortex. Standard terminology of the UTD classification system should be used for reporting. Staff performing postnatal US should use techniques and reporting standardized according to the UTD classification system for maximal consistency across studies.[18]
11. **For those patients with indications for postnatal US, a minimum of 2 postnatal renal US should be obtained prior to discontinuation of UTD surveillance.** If UTD is resolved at initial US, at least 1 additional US should be repeated 3 to 6 months later to ensure continued resolution. One study showed that 21% to 28% of children with antenatal UTD had a normal initial postnatal US, but 45% of those patients had a follow-up US that was again abnormal.[111]
12. **For patients identified as *low-risk* (UTD P1) after their initial postnatal US, repeat US should be obtained in 3 to 6 months. Evaluation with VCUG/ceVUS or renal functional imaging, as well as use of antibiotic prophylaxis, is NOT recommended.** Postnatal surveillance with US should be driven by the likelihood of resolution, which occurs in most UTD P1 patients between 24 and 48 months of age.[3,112] Zee et al reported that 90% of UTD P1 patients reached resolution by 48 months.[1] Braga et al also reported that 90% reached resolution by 4 years.[2]

    The degree of UTD is not predictive of the presence or severity of VUR and, thus, should not be the sole factor used to determine the need for postnatal VCUG/ceVUS. The risk of UTI should be the main determinant for the need for a VCUG. Two large patient registries have examined risk factors for UTI and utility of antibiotic prophylaxis in children with UTD, and it is agreed upon that patients in this low risk category (UTD P1) receive the least benefit from early VCUG and antibiotic prophylaxis.[4,112] The risk of significant obstructive uropathy in a low-risk child is less than 1%, and thus renal functional imaging is not warranted unless there is worsening dilation over time.[1,2]
13. **For patients identified as *intermediate-risk* (UTD P2), after their first postnatal US, a repeat US should be obtained in 1 to 3 months. Evaluation with VCUG/ceVUS or renal functional imaging, as well as use of antibiotic prophylaxis, should be considered on the basis of a patient's individualized risk.** There is less robust evidence about the utility of VCUG/ceVUS, prophylactic antibiotics and renal functional imaging in the intermediate risk group in preventing UTI and renal function sequelae. An informed

discussion utilizing a shared decision-making approach should be conducted with the family about risks and benefits of testing and antibiotics, as well as chance of future UTI, rate of detection of VUR, its treatment, and natural history.[4,112]

14. **Ureteral dilation (unilateral or bilateral) ≥7 mm increases the risk of UTI. Antibiotic prophylaxis decreases this risk and is recommended as well as a VCUG/ceVUS in this population.**[71] Other factors that may increase UTI risk include female gender, intact foreskin, and certain specific diagnoses.[3,4] **In follow-up, clinicians should consider stopping antibiotic prophylaxis at 12 months of age, unless the child has VUR or persistent ureteral dilation ≥7 mm.**
15. **For patients identified as *high-risk* (UTD P3), a repeat US should be obtained 1 month after their first postnatal US. VCUG/ceVUS, antibiotic prophylaxis, and renal functional imaging are recommended in this group.** This group is known to be at highest risk for urinary tract infection, deterioration of kidney function and need for surgery.[3,4,112] VCUG/ceVUS can be obtained during the birth hospitalization or at the time of second US if there is no concern for conditions leading to bladder outlet obstruction, like posterior urethral valves. If persistent UTD P3 is visualized, a renal functional imaging is usually obtained at 6 to 12 weeks of age. If vesicoureteral reflux is ruled out on VCUG/ceVUS, duration for use of prophylactic antibiotics depends on suspected diagnosis.
16. **If indicated, renal functional imaging should be deferred until at least 6 to 12 weeks of age to allow for appropriate development of renal blood flow, which optimizes the accuracy of testing.** During the first months of life, kidney immaturity results in low uptake of 99mTc-MAG3 and slower cortical transit times. Renal functional studies performed before 6 to 12 weeks may over- or underestimate the kidney function and are not generally predictive of outcome.[63,64]
17. **Any patient with UTD may be referred postnatally to nephrology and/or urology depending on provider comfort level with surveillance of UTD and counseling parents on implications on overall health and natural history.** Nephrology and/or urology consultation is **recommended** early in children in whom the risk of kidney deterioration or need for surgery is high (UTD P2-3) to allow for early shared decision making. Virtual/telemedicine consultation is appropriate.
18. **Any child with known UTD and a fever should be considered for the evaluation of UTI, especially those that have not undergone lower urinary tract imaging. If a febrile UTI is diagnosed in a patient with known UTD, then a VCUG/ceVUS should be performed to evaluate for VUR.** A catheterized urine specimen is preferred if initial urine analysis is suggestive of UTI to minimize rate of contamination and overtesting and treatment. There is not consensus on the need for urine testing with fever and presence of upper respiratory symptoms/other possible sources of fever; however, it should be stated that a high index of suspicion for concomitant UTI, even in the presence of other symptoms, should be maintained. Clinical suspicion should guide evaluation, and a shared decision-making approach should be used.

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ABBREVIATIONS

APD: anteroposterior renal pelvis diameter
CAP: continuous antibiotic prophylaxis
ceVUS: contrast-enhanced voiding urosonography
MRU: magnetic resonance urography
RBUS: renal and bladder ultrasonography
RS: renal scintigraphy
SFU: Society for Fetal Urology
UPJ: ureteropelvic junction
US: ultrasonography
UTD: urinary tract dilation
UTI: urinary tract infection
VCUG: voiding cystourethrogram
VUR: vesicoureteral reflux
99mTc-DMSA: technetium-99m-labeled-dimercaptosuccinic acid
99mTc-DTPA: technetium-99m-labeled-diethylenetriamine penta-acetic acid
99mTc-MAG3: technetiumm-99m-labeled mercaptoacetyl triglycine

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