Assessment and Management of Fetal Hydronephrosis

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Objectives After completing this article, the reader should be able to:

1. Differentiate genitourinary abnormalities associated with hydronephrosis detected on fetal ultrasonography.
2. Describe the type of fetal hydronephrosis that requires a complete uroradiologic evaluation.
3. Characterize the complete postnatal uroradiologic evaluation of significant fetal hydronephrosis.
4. Delineate the factor that sets the timetable for postnatal uroradiologic evaluation.
5. Describe the neonates for whom diuretic renography is reserved.

Introduction

Ultrasonographic detection of antenatal anomalies in the fetus has increased steadily since its initial widespread use in the 1970s. During these early years, antenatal ultrasonography detected structural abnormalities in approximately 1% to 3% of all pregnancies. (1) Currently, it is estimated that genitourinary anomalies comprise 20% of all antenatally detected fetal anomalies. (2) In a recent British population-based study, fetal genitourinary anomalies were identified in 2.3% of women undergoing routine obstetric ultrasonography between 18 and 23 weeks of gestation. (3) Hydronephrosis clearly has become the most commonly detected antenatal anomaly on fetal ultrasonography.

Detection of antenatal dilation of the urinary tract does not always indicate postnatal urinary tract obstruction or even a significant genitourinary anomaly. (4) Among infants diagnosed as having prenatal hydronephrosis or other genitourinary anomalies, the question often is raised about the need for and extent of the postnatal evaluation to assess the magnitude of this commonly detected antenatal anomaly. The purpose of this review is to provide a framework for assessment and management of antenatally detected hydronephrosis.

Differential Diagnosis

Fetal hydronephrosis is a nonspecific finding that can be associated with multiple congenital anomalies of the genitourinary tract. A thorough understanding of disorders that can result in hydronephrosis postnatally allows the physician to assess the need for postnatal diagnostic tests and guide treatment recommendations. The congenital anomalies that may result in hydronephrosis can be categorized as disorders of urinary reflux and disorders of urinary obstruction. It can be difficult to distinguish between these two categories unequivocally in the prenatal period. Certain characteristics of prenatal hydronephrosis and sequential fetal imaging may assist in making this distinction.

Disorders of Urinary Reflux

Disorders of urinary reflux largely fall into the category of primary vesicoureteral reflux (VUR). This problem results in retrograde flow of urine from an anomalous connection of...
the ureter to the bladder. A deficiency in the length of the submucosal ureteral tunnel within the bladder is the anatomic pathology often associated with retrograde flow of urine into the ureter. In essence, a flap valve mechanism has failed at the ureterovesical junction (UVJ). Urinary reflux can occur unilaterally or bilaterally. Reflux has varying degrees of either hydronephrosis or hydroureter. It can be present in solitary or duplex collecting systems. Urinary reflux also can be seen in association with other, more complex congenital urinary anomalies, such as prune belly syndrome, primary megaureter, myelomeningocele, and posterior urethral valves.

**Disorders of Urinary Obstruction**

Congenital anomalies resulting in obstruction to urinary flow also can cause hydronephrosis. The usual locations for the obstruction are the transition points in the urinary collecting system, including primary obstruction at the ureteropelvic junction (UPJ), the UVJ, and the posterior urethra (in males). The urinary collecting system is dilated in all portions proximal to the point of obstruction. UPJ and UVJ obstructions more commonly are unilateral, but they can be bilateral. All obstructions can vary from high-grade (complete) to low-grade (partial). The high-grade obstructions cause severe damage to the parenchymal components of the kidney. Obstructions at the UPJ can result from a high insertion of the ureter on the renal pelvis, ureteral stricture at the junction, or anomalous crossing vessels to the lower pole segment of the kidney. Perhaps the ultimate form of obstruction at the UPJ is failure of the ureter to join during development, which results in cystic degeneration of the renal parenchyma, commonly referred to as multicystic dysplastic kidney (MCDK). Obstruction at the UVJ usually results from intrinsic ureteral stricture at the junction or an adynamic segment of ureter just proximal to the junction.

The most devastating of the obstructive disorders occurs at the posterior urethra in males only and results from obstructing valve leaflets. As with other forms of obstruction, posterior urethral valves (PUV) cause dilation of all components of the collecting system above this point. Hence, dilation of the posterior urethra and bladder and both the ureters and kidneys is seen frequently. Oligohydramnios often is associated with PUV or any combination of high-grade bilateral obstructions. These disorders require rapid evaluation and management at birth.

Completely duplicated urinary collecting systems also may be associated with hydronephrosis resulting from obstruction. The two commonly associated causes of obstruction in duplicated systems are an upper pole ectopic ureter or an upper pole ureterocele. Hydroureteronephrosis commonly is identified in these cases. The lower pole segment more frequently has a reflexing associated anomaly. Other congenital genitourinary disorders that may be diagnosed prenatally and may be associated with hydronephrosis are bladder extrophy, renal tumors, cloacal anomalies, intersex states, and hypospadias.

**Embryology**

The spectrum of genitourinary anomalies and the timing of the appearance of fetal hydronephrosis are best understood in light of the embryology of the ureteral bud. The ureter begins development at approximately the end of the fourth week of embryonic life as a bud originating from the mesonephric (wolfian) duct. The ureteral bud grows rapidly to penetrate the metanephric blastemal ridge by the fifth week of gestation. The ureter is a solid cord until the sixth week of gestation, at which time it begins canalization from the midsection, proceeding to the UPJ and UVJ. Urine begins to flow through the ureter at the 10th week of gestation. Hydroureteronephrosis can be identified initially in the fetus during the 13th and 14th weeks of gestation. By the 18th week of gestation, nearly all the amniotic fluid is fetal urine. Hence, customary screening obstetric ultrasonography for fetal anomalies performed from the 16th to 20th weeks of gestation often reveals anomalies of the genitourinary tract.

**Threshold for Evaluation: Prenatal and Postnatal Correlates**

Currently, no uniform mechanism can evaluate the effects of hydronephrosis on the prenatal kidney or definitively predict the need for postnatal intervention. Many large university centers are collecting prospective data that may determine which neonates require a complete postnatal evaluation for their prenatally detected hydronephrosis. Until the time when these data mature, we must rely on a selected number of studies that have limited sample sizes and often are retrospective to provide responsible guidelines for postnatal evaluation. In the antenatal period, the anteroposterior (AP) diameter of the renal pelvis in a transverse renal image (Fig. 1) has been used as a quantitative parameter for monitoring the degree of hydronephrosis. Others have proposed surveillance with measurements of the visibly fluid-filled collecting system in the sagittal plane.

Corteville and associates were among the first investigators to try to assess antenatal hydronephrosis
objectively and correlate the antenatal findings with the need for postnatal intervention. They determined that an AP renal pelvic diameter was the most useful measurement for diagnosing congenital hydronephrosis that subsequently was associated with abnormal postnatal renal function or the need for surgical intervention. A threshold of 4 mm dilation before 33 weeks’ gestation and 7 mm after 33 weeks’ gestation was advocated. They reported a sensitivity of 100% for confirmed postnatal renal pathology, but conceded a false-positive rate of 24% at near term. Of the 63 fetuses that had antenatal hydronephrosis in their study, only 45 had confirmed hydronephrosis at birth. Using the AP diameter threshold values outlined, they could predict the 31 fetuses requiring postnatal surgery for the antenatally detected hydronephrosis.

Other groups have reassessed the use of the AP diameter of the renal pelvis to predict the need for postnatal evaluation of the kidneys for significant pathology. Anderson and colleagues (7) reported that simple measurement of the AP diameter of the renal pelvis at 16 to 24 weeks of gestation could not differentiate between obstructed and unobstructed kidneys in fetuses that had AP diameters greater than 4 mm. Instead, they concluded that the AP diameter increases at a greater rate during pregnancy in kidneys that are obstructed than in those that are not obstructed.

Zerin and associates (4) were the first to assess the incidence of VUR in a cohort of patients that had antenatally detected hydronephrosis. They reviewed the clinical records of 130 patients who had fetal hydronephrosis and complete postnatal uroradiologic imaging with voiding cystourethrography (VCUG) and renal bladder ultrasonography (RBUS) within 6 months of birth. The mean age at imaging with RBUS was 22 days, and the mean age at imaging with VCUG was 38 days. VUR was demonstrated in 49 patients (38%). The incidences of the most common urologic anomalies in their cohort were 38% for VUR, 31% for UPJ obstruction, 13% for duplex system with ureterocele, 12% for MCDK, and 7% for primary megaureter. Prune belly, PUV, ectopic ureters, and single-system ureterocele also were detected in the fetal period at incidences of less than 5%.

Sairam and colleagues (3) reported the first prospective study assessing the outcome of fetal hydronephrosis detected in an unselected obstetric population. The fetal hydronephrosis rate was 2.3% in their study population of 11,465 women evaluated at 18 to 23 weeks’ gestation using the criteria of AP renal pelvis diameter greater than 4 mm. They categorized patients into mild hydronephrosis (AP diameter >7 mm). The hydronephrosis resolved antenatally or in the early postnatal period in 88% of the fetuses that had mild hydronephrosis. None of the fetuses that had mild hydronephrosis (4 to 7 mm) and only one in three fetuses that had moderate/severe hydronephrosis (>7 mm) required postnatal surgery. This prospective study illustrates that a large number of fetal hydronephrosis cases may represent a simple physiologic dilation that is unlikely to cause significant morbidity.

The challenge is to find additional parameters that may predict better which fetuses that have congenital hydronephrosis will have significant postnatal renal pathology requiring intervention. Currently, most physicians caring for neonates who have persistent dilation with an AP diameter greater than 7 mm would proceed with a postnatal evaluation. Fetal hydronephrosis with an AP diameter measuring between 4 to 7 mm is the group of neonates for whom there is no clear consensus for the magnitude of postnatal imaging evaluation. Until data from large prospective studies are available, the safest approach probably is to conduct a postnatal uroradiologic evaluation.

**Immediate Postnatal Evaluation**

A clear understanding of the differential diagnosis of the fetus that has hydronephrosis allows the development of an algorithm for postnatal evaluation and management that provides quality care for the neonate, preserves established medical relationships, and minimizes postnatal physician visits. In most cases of fetal hydronephrosis, there is no indication for early delivery of the neonate or the need for a tertiary care hospital. Management and evaluation can be started with the primary care clinician in the nursery at birth. Certain high-risk fetuses require delivery in a setting where tertiary care services are immediately available. These include the male fetus that has severe bilateral hydronephrosis and a distended urinary bladder (suspicious for PUV), the fetus that has severe oligohydramnios associated with hydronephrosis, and the fetus in which hydronephrosis is one of multiple congenital anomalies.

Initial evaluation of the neonate begins with a physical examination to assess the immediate need for urologic consultation or emergent transfer to a facility that can provide these services. The notable findings on physical examination of the neonate who has fetal hydronephrosis are a palpable flank mass, a distended urinary bladder, a firm walnut-shaped bladder, and respiratory distress. Solitary serum electrolyte and serum creatinine levels at birth are not particularly useful because they are reflective...
of maternal renal function only at that time. For the neonate who has severe bilateral hydronephrosis, such levels may serve as a baseline for subsequent comparisons. The timing of the uroradiologic evaluation is dictated by the urgency of the clinical presentation. In high-risk cases (Table 1), evaluation should begin prior to discharge from the hospital with an appropriate pediatric urology/nephrology consultation. For less urgent clinical presentations (ie, fetuses that have unilateral mild hydronephrosis), the neonate who has fetal hydronephrosis can be evaluated in the outpatient setting within the first 4 to 6 weeks after birth.

The neonate who has significant fetal hydronephrosis and will undergo a complete urologic imaging evaluation should receive prophylactic antibiotic therapy to protect the genitourinary system from a urinary tract infection because of the high incidence of VUR in these patients (approximately 38%). The medications of choice in the early neonatal period are amoxicillin or cephalexin. Once the neonate is older than 2 months of age, trimethoprim/sulfamethoxazole can be administered safely as a prophylactic agent. The dose of any prophylactic antibiotic is 25% of the usual 24-hour treatment dose administered once daily.

Postnatal Imaging Studies
A systematic approach to postnatal imaging studies is essential to minimize the number and invasiveness and maximize the diagnostic yield. Many cases that have similar prenatal ultrasonographic findings of hydronephrosis ultimately have markedly different postnatal diagnoses and outcomes (Fig 2).

For fetal hydronephrosis that has a nonemergent clinical presentation at birth, the first imaging study should be renal bladder ultrasonography, ideally performed at approximately 72 hours after birth to avoid the earlier period of neonatal oliguria that may confound the ultrasonographic findings. Follow-up ultrasonography should be performed in 4 to 6 weeks to assess any interval change in the degree or nature of the hydronephrosis. For neonates who have emergent clinical presentations, the initial ultrasonography should be performed within hours of birth (once the clinical situation is stabilized) to assess the need for intervention.

Postnatal ultrasonography is most objective if the findings related to hydronephrosis are reported according to the grading system developed by the Society for Fetal Urology (SFU) (Table 2). This scale uses defined criteria for serial comparisons of the degree of hydronephrosis. The grading system employs three factors to establish a hydronephrosis grade: dilation of the renal pelvis, dilation of the renal calyces, and atrophy of the renal cortex.

VCUG is an essential part of the evaluation of fetal hydronephrosis. Zerin and associates (4) documented that 38% of their cases of fetal hydronephrosis had VUR diagnosed postnatally. More importantly, they reported that 25% of the diagnosed cases of VUR had normal findings on initial postnatal ultrasonography. This is not surprising because low-grade VUR (grades I and II) often can be seen when renal bladder ultrasonographic findings are normal. Figure 3 illustrates the case of a neonate in whom only left-sided fetal hydronephrosis was detected. In a recent study (8), VCUG abnormality was noted in 7.6% of infants in whom findings on both initial and follow-up ultrasonography were normal. Among those who had abnormal findings on ultrasonography, 33% had abnormal VCUG results.

For the neonate who has a nonemergent clinical presentation, VCUG frequently can be performed at the time of follow-up ultrasonography (4 to 6 wk) to maximize the efficiency of testing and office visitations. The VCUG must be a fluoroscopic study in males because the anatomic details of the male’s urethra are needed for complete evaluation (Fig. 4). Either a fluoroscopic or nuclear VCUG may be performed in the female because anatomic details of the female urethra are not essential.

Table 1. Fetal Ultrasonographic Findings Necessitating an Emergent Evaluation

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<th>Grade</th>
<th>Ultrasonographic Findings</th>
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<tbody>
<tr>
<td>0</td>
<td>No splitting of renal pelvis</td>
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<tr>
<td>1</td>
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<tr>
<td>2</td>
<td>Splitting confined to sinus; calyces not dilated</td>
</tr>
<tr>
<td>3</td>
<td>Renal pelvis dilated beyond sinus; calyces uniformly dilated</td>
</tr>
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<td>4</td>
<td>Renal parenchyma thinned to &lt;50% the contralateral side</td>
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Table 2. Society for Fetal Urology Hydronephrosis Grading System

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A fluoroscopic VCUG may prove more generally informative as the initial study because anatomic details of the collecting system may not be evident in the nuclear VCUG (Fig. 5). VCUG imaging must be obtained during the voiding phase because some VUR occurs only during a detrusor contraction.

Diuretic renography may be needed to differentiate high-grade urinary obstruction from partial or nonobstructing hydronephrosis. Renography should be considered only if the hydronephrosis persists and the diagnosis of VUR has been eliminated by normal findings on VCUG. Renography is not necessary in all cases of persistent hydronephrosis on follow-up ultrasonography imaging. It should be performed routinely if there is significant renal pelvis dilation (AP diameter >1.2 cm) and postnatal caliectasis (SFU grades 3 and 4). For optimal utility, diuretic renography should be performed only after the first month of age (adjust for prematurity). This test provides two valuable pieces of information concerning renal function: differential renal function and obstruction to urinary flow. Differential function should be 50% for the right kidney and 50% for the left kidney when the two renal units function well. A differential function below 35% for either kidney signifies substantial compromise of renal cortical function. The uptake and excretion curves may be the most important aspects of the study because they objectively define high-grade obstruction of urinary flow (Fig. 6). In the setting of high-grade obstruction to flow, early surgical intervention may be undertaken to alleviate the obstruction. This will result in restoration of urinary drainage on postnatal imaging studies (Fig. 7).

It is appropriate to consider discontinuing antibiotic prophylaxis for the neonate who has good renal function, no VUR, and no evidence of high-grade urinary obstruction because there is minimal risk for pyelonephritis.

The sequence of testing outlined previously will provide a definitive diagnosis for the neonate who has fetal hydronephrosis within the first 2 months of life. It streamlines the process and minimizes the use of invasive testing. If hydronephrosis without obstruction or hydronephrosis with partial obstruction is the ultimate diagnosis, sequential ultrasonography until resolution is advised. The frequency of the ultrasonography in the first year of life should be approximately every 3 months because of the rapid renal growth. This may be tapered to once a year by age 3 years. Surveillance may be stopped at any time once the hydronephrosis is resolved or stabilized (low-grade hydronephrosis, SFU grade 1 or 2), as confirmed on sequential ultrasonography.

Conclusion

As additional outcome data on antenatally detected hydronephrosis from large prospective studies become available, the evaluation and management algorithms for fetal hydronephrosis will be modified. Additionally, the advent of newer modalities of fetal imaging (eg, fetal magnetic resonance imaging) that allow more anatomic and even functional details will have an impact on postnatal algorithms (Fig. 8). Obstetric ultrasonography has changed forever the diagnosis and management of congenital genitourinary anomalies in the neonate. The decade-old debates of whether to salvage or remove a kidney have progressed to new debates about if, when, and how to evaluate fetal hydronephrosis. This paradigm shift hopefully will spare future generations of children the renal insufficiency that was unavoidable in the past.

References

7. Use of antenatal ultrasonography can allow early detection of fetal anomalies. Of the following, the most common fetal anomaly detected by antenatal ultrasonography is:
   A. Chylothorax.
   B. Congenital heart disease.
   C. Duodenal atresia.
   D. Hydrocephalus.
   E. Hydronephrosis.

8. The spectrum of genitourinary anomalies and the timing of the appearance of fetal hydronephrosis are best understood in light of the embryology of the ureteral bud. Of the following, the most accurate statement regarding ureteral development is that:
   A. Amniotic fluid contains primarily fetal urine by the 14th week of gestation.
   B. Canalization of the ureter proceeds in a cephalocaudad direction.
   C. Hydronephrosis can be identified initially at the 10th week of gestation.
   D. The ureteral bud begins in the metanephric blastemal ridge.
   E. The ureter is a solid cord until the 6th week of gestation.

9. Fetal ultrasonography performed at 20 weeks’ gestation reveals an anteroposterior renal pelvis diameter of 8 mm. Of the following, the most likely cause of hydronephrosis in this fetus would be:
   A. Duplex system with ureterocele.
   B. Multicystic dysplastic kidney.
   C. Primary megaureter.
   D. Ureteropelvic junction obstruction.
   E. Vesicoureteral reflux.

10. A male infant born at term has a palpable flank mass on each side of the abdomen as well as suprapubic fullness. The urine stream is poor. The maternal history is significant for severe oligohydramnios. Of the following, the initial imaging study warranted in this infant is:
    A. Abdominal ultrasonography.
    B. Diuretic renography.
    C. Magnetic resonance imaging.
    D. Radionuclide renal scan.
    E. Voiding cystourethrography.