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Antenatal Hydronephrosis – A Review

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ABSTRACT
Antenatal hydronephrosis, the dilation of the fetal urinary tract, is a common prenatal finding, often detected during routine ultrasound screenings. This condition arises from a variety of factors, including Vesicoureteral reflux, Lower urinary tract obstruction (LUTO), Ureterocele, posterior urethral valve, congenital ureteric strictures impacting the kidney's drainage system. Its accurate assessment is essential to guide appropriate management strategies and optimize outcomes. Numerous grading systems, such as APD Grading System, the Society of Fetal Urology (SFU) and the Urinary Tract Dilatation (UTD) classification, aid in evaluating the severity of antenatal hydronephrosis by considering factors like renal pelvis dilation, calyceal involvement, and parenchymal changes. Prognostication and management recommendations, based on these assessments, are essential for determining the need for postnatal follow-up, medical intervention, or surgical procedures. Regular monitoring, including renal ultrasounds and other imaging modalities, helps track the progress of hydronephrosis, especially in cases of higher severity or associated anomalies. Early diagnosis and appropriate care can significantly impact the outcomes, ensuring the well-being of infants with antenatal hydronephrosis.

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I. INTRODUCTION

Antenatal hydronephrosis (ANH) or prenatal hydronephrosis pertains to the expansion of the renal pelvis collecting system, a common discovery in antenatal ultrasound exams occurring in approximately 0.6–4.5% of pregnancies [Blyth B, 1993]. ANH encompasses a broad range of urological conditions, spanning from transient dilation of the collecting system to medically significant urinary tract blockages or vesicoureteric reflux (VUR). A combination of ten terms referring to hydronephrosis (hydronephrosis, pelviectasis, pelvocaliectasis, pyelectasis, hydroureteronephrosis, renal pelvic dilation (RPD), anteroposterior diameter (APD), oligohydramnios, calyceal dilation, and ureteral dilation) and six terms referring to the prenatal stage (prenatal, newborn, antenatal, fetal, prenatal diagnosis, and natural history) was utilized [Nguyen et al 2010]. The clinical significance of ANH hinges on its severity, with more severe cases aligning with heightened occurrences of medically consequential conditions [Pates JA, 2006]. Antenatal hydronephrosis is considered to be present if the fetal renal pelvis diameter measures equal to or greater than 4 mm during the 2nd trimester scan and equal to or greater than 7 mm in the 3rd trimester scan. Its classification spans mild, moderate, and severe categories, determined by the size of the renal pelvic anteroposterior diameter (APD). The upper limit for a normal renal anteroposterior diameter in the third trimester is 7 mm. An AP diameter measuring equal to or greater than 7 mm at 18 weeks (second trimester) signifies a fetus prone to postnatal reflux or experiencing an obstruction.

II. ETIOLOGY

Pelvi-ureteric junction obstruction (PUJO)- It refers to the functional or anatomical hindrance of urine flow at the ureteropelvic junction. Among neonates, this obstruction at the ureteropelvic junction is the leading cause of obstructive hydronephrosis and exhibits a predominance in males and on the left side [Epelman M, 2012]. The primary pathological trigger of antenatal hydronephrosis is commonly associated with Ureteropelvic Junction Hydronephrosis (UPJHN), accounting for approximately 10-30% of cases [Nguyen HT, 2010]. This condition is

typically unilateral, sporadic, and predominantly affects the left side [Churchill BM, 2001]. The precise cause of ureteropelvic junction obstruction remains unclear, often attributed to a narrowed and functionally inactive segment leading to the obstruction [Babu R, 2019]. Ultrasonographic observations of ureteropelvic junction obstruction conform to the standard pattern of obstruction: expansion of the upstream structure and constriction of the downstream structure following the transition point. Ultrasound images of the affected kidney reveal multiple uniformly enlarged calyces that connect to an expanded renal pelvis. This expansion is abruptly restricted at the ureteropelvic junction level, although the ureter itself remains undilated in bladder scans [Siegel MJ, 2011].

Vesicoureteral reflux (VUR) - It refers to the abnormal backward flow of urine from the bladder into the ureter and possibly the kidney. This condition is believed to emerge from a developmental anomaly at the ureterovesical junction, where factors such as lateralization or enlargement of the ureteral orifice, inadequate longitudinal muscle fibers in the submucosal ureter, or its shortened length might be involved [Bates DG, 2013]. Detection of varying degrees of hydronephrosis or hydroureteronephrosis can suggest the presence of vesicoureteral reflux [Nguyen HT, 2010]. VUR gives rise to two interconnected outcomes: urinary tract infections (UTIs) and renal scarring [Jakobsson B, 1992]. Children experiencing UTIs exhibit a high prevalence of VUR [Jacobson SH, 1999]. The term "reflux nephropathy" denotes the connection between renal scarring and VUR. Children with VUR are more susceptible to scarring after a UTI, likely due to the heightened risk of renal involvement [Jakobsson B, 1994]. In instances of severe hydronephrosis, the reflux associated with it could be prompted by transient obstruction of the posterior urethra during fetal development [Avni EF, 1992].

Lower urinary tract obstruction (LUTO) - It is characterized by an obstruction in the outflow of the bladder during fetal urinary tract development. This obstruction leads to a progressive enlargement of the bladder, thickening of its walls, and subsequently, hydro-ureteronephrosis. It also causes compression of kidney parenchyma and a reduction in the production of amniotic fluid [Morris, R. K. & Kilby, 2008]. A significant complication of fetal LUTO is kidney hypodysplasia, which falls within the spectrum of congenital kidney and urinary tract anomalies [Matsell, D. G., 2002].

The most prevalent causes of LUTO include posterior urethral valves (PUVs) and urethral atresia [Ruano, R. et al. 2015] Less common causes encompass anterior urethral valves, megalourethra, cloacal malformations, and prolapsing ureterocele [Nguyen, H. T. et al. 2014]

Megaureter- It refers to the enlargement of the ureter [Hodges SJ, 2010]. Primary megaureter pertains to the dilation of the ureter without an identifiable anatomical cause at the vesicoureteral junction. Within primary megaureter, there are three subtypes: obstructed primary megaureter, refluxing primary megaureter, and nonrefluxing unobstructed primary megaureter [Berrocal T, 2002]

The posterior urethral valve- It is thought to be the result of congenital membrane folds arising from the Wolffian duct, generating different degrees of blockage at the junction of the penile and posterior urethras. [Berrocal T, 2002] This condition is suspected when prenatal ultrasound reveals bilateral hydroureteronephrosis in association with a thick-walled bladder and reduced amniotic fluid levels [Epelman M, 2012]

Ureterocele, ectopic ureter, and duplex system are related conditions that can be identified through specific findings in prenatal imaging. Upper pole hydroureteronephrosis accompanied by a thin-walled cystic structure situated at the bladder base points towards a diagnosis of ureterocele. On the other hand, the same upper pole hydroureteronephrosis without an associated intravesical cystic structure suggests an ectopic ureter. Both of these conditions are often linked to a duplex system, wherein there are two ureters originating from a single kidney [Mallik M, 2008]

There are also less common prenatal conditions that can lead to hydronephrosis, including prune belly syndrome, cystic kidney disease, congenital ureteric strictures, and megalourethra.

III. SYMPTOMS

Antenatal hydronephrosis refers to the dilation of the renal pelvis detected before birth. Oligohydramnios, a reduced amount of amniotic fluid (defined as amniotic volume less than 500 cc or an AFI < 5-6), can indicate severe and bilateral renal involvement. Oligohydramnios can be caused by factors like amnion nodosum, amniotic fluid leakage, urinary tract obstruction, and renal dysplasia. The potential consequences of oligohydramnios encompass pulmonary hypoplasia, Potter's syndrome (characterized by distinct facial features, limb deformities, and other anomalies), and limb abnormalities [Nguyen HT,2010] In cases involving posterior urethral valves, the level of amniotic fluid can significantly predict renal function and clinical outcomes [Oliveira EA, 2002]

Postnatal hydronephrosis (PNH) can arise from various conditions affecting the kidneys and urinary collecting system. Most infants with PNH do not display symptoms, underscoring the importance of prenatal diagnosis through ultrasound [Sadeghi-Bojd S, 2016]

Urinary stasis in PNH raises the risk of urinary tract infections, the most common complication. The severity of hydronephrosis influences the increased risk and severity of urinary infections. Symptoms of a urinary

tract infection can include a strong urge to urinate, painful urination, cloudy or foul-smelling urine, back pain, and fever

In an infant, the presence of a palpable abdominal mass can be indicative of various renal conditions. For instance, conditions like multicystic dysplastic kidney (MCDK), ureteropelvic junction (UPJ) obstruction, or autosomal recessive polycystic kidney disease (ARPKD) might result in a detectable abdominal mass. Similarly, a palpable bladder in infants may be linked to disorders like posterior urethral valves (PUV), urethral atresia, or urethral stricture [Becker AM. 2009]

Multicystic dysplastic kidney is a frequently encountered renal abnormality. Ultrasound typically reveals noncommunicating cysts of varying sizes, absence of distinguishable renal parenchyma, and atretic proximal ureters as characteristic findings of MCDK [Feldenberg LR, 2000]

Prune belly syndrome arises from early urethral obstruction, leading to extensive bladder distention and degeneration of the abdominal wall musculature. This syndrome is associated with anomalies in multiple systems, including gastrointestinal, pulmonary, cardiac, and orthopedic systems [Strand WR. 2004]

In some cases, a prolapsed ureterocele can manifest as a cystic mass at the introitus. This condition can also contribute to palpable masses in infants.

IV. DIAGNOSIS

Antenatal hydronephrosis is often considered a physiological condition that tends to resolve either during pregnancy or within the first year of an infant's life [A.A. SHOKEIR and R.J.M. NIJMAN 2000]. The effectiveness of prenatal ultrasound in detecting fetal urinary tract abnormalities is widely recognized [Ewigman BG, 1993]. Characterising foetal hydronephrosis entails determining its severity, laterality, potential relationship with ureteric dilatation, renal parenchymal alterations, and bladder size, thickness, and emptying anomalies. The existence of oligohydramnios at the same time is a key factor in deciding prognosis. [A.A. SHOKEIR and R.J.M. NIJMAN ,2000].

Various methods are employed to detect antenatal hydronephrosis. The anteroposterior renal pelvic diameter (APRPD) measurement is one approach, and the Society of Fetal Urology (SFU) grading system is another. The SFU grading system is valuable for academic evaluations. However, it can be challenging to apply and evaluate practically during the intrauterine period. As a result, the APRPD measurement is the more commonly used method and holds high practical value [Aksu N, 2005]

The APD Grading System-The APD Grading System involves measuring the anteroposterior renal pelvic diameter (APDRP) primarily at the parenchymal edge (hilus) during a transverse section of the kidney. It's important to note that the renal pelvis and its anteroposterior diameter are dynamic measurements, which can change significantly based on factors like hydration, bladder filling, body position (supine or prone), and respiration [Timberlake MD, 2013]

In the case of antenatal hydronephrosis, a renal anteroposterior diameter (APD) of greater than 4mm during the second trimester and greater than 7mm during the third trimester is considered the cutoff for diagnosing the condition. Postnatal hydronephrosis is categorized as mild, moderate, or severe based on the measurement obtained and the gestational age. This grading system doesn't take into account the presence of calyceal dilation, an extra-renal pelvis, or parenchymal changes. A renal pelvic APD exceeding 7mm in a neonate and 1cm in an older child is considered abnormal and warrants further investigation and follow-up.

Gradation by antero posterior renal pelvic diameter

Classification of hydronephrosis	Antero posterior diameter	
	Second Trimester	Third Trimester
Mild	4-6mm	7-9mm
Moderate	7-10mm	10-15mm
Severe	>10mm	>15mm

The Society of Fetal Urology (SFU) Grading System- It is a comprehensive approach that considers renal pelvic dilation, calyceal dilation, and parenchymal thinning. This system is both quantitative and subjective, and it includes measurements of renal cortical or parenchymal thickness, particularly in postnatal follow-up of hydronephrosis [Namdev R,].

Here are the different grades within the SFU system:

- Grade 0: No dilatation; calyceal walls are opposed to each other.
- Grade 1 (Mild): Dilatation of the renal pelvis without dilatation of the calyces (can also occur in the extrarenal pelvis); no parenchymal atrophy.

- Grade 2 (Mild): Mild dilatation of the renal pelvis and calyces (pelvicalyceal pattern is retained); no parenchymal atrophy.
- Grade 3 (Moderate): Moderate dilatation of the renal pelvis and calyces; blunting of fornices and flattening of papillae; mild cortical thinning may be seen.
- Grade 4 (Severe): Gross dilatation of the renal pelvis and calyces, with a ballooned appearance; loss of borders between the renal pelvis and calyces; renal atrophy seen as cortical thinning.

The UTD (Urinary Tract Dilatation) Classification- It was introduced in 2014, aims to address the limitations of previous grading systems, such as the APRPD and SFU systems, by providing a unified description of urinary tract dilation [Nguyen HT, et al., 2014]. This classification system recommends using the term "UT dilatation" consistently and avoiding non-specific terms like "hydronephrosis" or "pelvicaliectasis." A pelvic anteroposterior (AP) diameter exceeding 1 cm is considered significant during any ultrasound scan of the renal system. The UTD classification system merges various grading systems, allowing for better communication and management consistency across different cases.

Prognostication and management guidance based on the UTD Classification:

- **Antenatal Assessment:**
- UTD A1 (Low Risk): If diagnosed before 32 weeks, a repeat ultrasound scan is recommended after 32 weeks. If the scan beyond 32 weeks shows resolved renal architecture, no further antenatal follow-up is needed. If UTD A1 is still present, postnatal ultrasound scans are recommended at >48 hours and at 6 months.
- UTD A2-3 (Higher Risk): Monthly ultrasound assessments are recommended. Prenatal counselling sessions with Pediatric Nephrologists/Urologists are advised. Postnatal ultrasound scans are recommended at >48 hours and at 1 month (except for bilateral cases).
- **Postnatal Assessment:**
- UTD P1: Follow-up ultrasound in 1-6 months. Recommendations for Voiding Cystourethrogram (VCUG) and continuous antibiotic prophylaxis (CAP) are left to the treating physician's discretion, as management of asymptomatic vesicoureteral reflux (VUR) can vary.
- UTD P2: Follow-up ultrasound in 1-3 months. Need for VCUG, CAP, and functional scans are left to the treating physician's discretion.
- UTD P3: Follow-up ultrasound is recommended in 1 month. VCUG and CAP are recommended. Need for functional scans are at the discretion of the treating physician.
  The UTD classification system provides a more comprehensive and unified approach to the assessment and management of urinary tract dilatation in both antenatal and postnatal settings.

Antenatal Evaluation

Antenatal evaluation of hydronephrosis involves performing prenatal ultrasound scans, typically in the mid-second trimester. The identification of hydronephrosis, indicated by an anteroposterior renal pelvic diameter (APD) greater than 4 mm in the second trimester or greater than 7 mm in the third trimester, usually requires further follow-up during the prenatal period. Factors like gender, gestational age, presence of ureteral dilation, bilaterality, amniotic fluid volume status, and APD influence the frequency of imaging. Some cases require regular imaging throughout pregnancy, while others may have repeat ultrasounds deferred until late in the third trimester. In cases where the diagnosis is uncertain, magnetic resonance imaging (MRI) can provide additional anatomical information [Nguyen HT et al., 2010]

Suspicious findings for posterior urethral valves (PUV) such as oligohydramnios, dilated bladder, bilateral hydroureteronephrosis require continuous monitoring throughout pregnancy. A level 3 ultrasound should be conducted to exclude other organ system abnormalities. Depending on the severity of oligohydramnios, fetal imaging every 4 weeks may be necessary [Clark TJ et al.,2003]

In centers with the necessary facilities, biochemical examination of fetal urine can be considered to assess the severity of renal compromise. Serial changes in values provide more informative insights than a single value, but repeated invasive procedures come with an increased risk of premature labour and infection.

Post Natal Investigations

The initial postnatal evaluation of fetal hydronephrosis is influenced by the degree of hydronephrosis observed during fetal assessment. Stronger recommendations for further evaluation are made if the hydronephrosis is moderate to severe (fetal pelvic APD greater than 10 mm in the third trimester) or if it increases in severity during the third trimester compared to the second trimester [Lee RS, 2006]

For infants with normal findings, a repeat study is recommended at 4-6 weeks of age. Isolated mild hydronephrosis (unilateral or bilateral) requires sequential ultrasounds at 3 and 6 months, followed by 6-12 monthly ultrasounds until resolution. Worsening hydronephrosis demands closer evaluation. Higher grades of

hydronephrosis or dilated ureters may indicate underlying obstruction or vesicoureteral reflux (VUR). Diuretic renography is a valuable tool for detecting pelviureteric junction or vesicoureteral junction obstruction and determining the need for surgery [Sinha A et al.,2013]

Renal and bladder ultrasound (US) is the primary imaging modality for monitoring the urinary tract in pediatric patients. It is easy to use and radiation-free, making it suitable for following renal dilation detected prenatally and postnatally. For accurate results, postnatal ultrasound should be performed after 48 hours but before the end of the first week to account for neonatal physiological dehydration [Arger PH et al, 1985]

For infants with mild unilateral antenatal hydronephrosis (AHN), a postnatal ultrasound performed in the 4th week is more sensitive and specific for detecting obstructive issues. Regardless of the initial ultrasound findings, all infants with AHN should undergo a re-evaluation ultrasound at the 4th week [Ismaili K et al., 2003] Subsequent follow-up frequency can be every 3-6 months, then every 6-12 months, based on the severity indicators of hydronephrosis. Most infants with mild hydronephrosis (SFU Stage 1-2, APRPD <10 mm) don't pose significant long-term issues. Moderate hydronephrosis (APRPD 10-15 mm) can be safely followed up with ultrasound alone, provided families are informed about urinary tract infection (UTI) risks. Infants with APRPD >15 mm and SFU Stages 3-4 need closer monitoring. These patients require vigilance for enlargement of renal structures or increased cortical thinning [Hafez AT, 2002]

Magnetic resonance urography (MRU) provides functional assessment and detailed imaging without neonatal radiation exposure. While it's still in its developmental stage for prenatal hydronephrosis, MRU is valuable for diagnosing complex congenital malformations, duplex renal systems, ectopic urethral openings, and when external obstruction by aberrant blood vessels is suspected [Jones RA, 2004]

Diuretic renal scan (DRS), typically performed at 6-8 weeks of age, is commonly used to assess upper urinary tract obstruction in infants. It's recommended when two renal ultrasounds over a span of at least 3 months show no improvement or suggest worsening moderate hydronephrosis [Davenport MT, 2013]

V. THERAPY

Therapy for various urinary tract conditions in infants and neonates is tailored to the specific underlying issue:

1. **Posterior Urethral Valves (PUVs):** Infants with PUVs require early urethral catheterization, correction of electrolyte imbalances, treatment for potential complications, and referral for surgical intervention. A large anteroposterior renal pelvic diameter (APD) exceeding 20-30 mm predicts a higher likelihood (50-55%) of surgery [Thomas DF. 2010]. Cystoscopic ablation of the urethral valves is a recommended treatment [Sarhan O, et al. 2008]. In cases where the patient is at high risk and has reached relative maturity, early delivery may be recommended. Intrauterine infusion of normal saline can be considered to prolong pregnancy and allow fetal lung maturation.
2. **Bilateral Severe Hydronephrosis due to Pelviureteric Junction Obstruction (PUJO):** For neonates with bilateral severe hydronephrosis, close monitoring with serial ultrasound and radionuclide studies is crucial to identify worsening hydronephrosis and declining renal function. Careful evaluation of differential function and estimated glomerular filtration rate (GFR) is important [Sinha A, et al. 2013].
3. **Antibiotic Prophylaxis:** Patients with moderate or severe hydronephrosis and/or dilated ureter should receive antibiotic prophylaxis while awaiting investigations. Mild hydronephrosis carries a lower risk of urinary tract infection (UTI), so antibiotic prophylaxis is not typically required [Alconcher LF, Tombesi MM. 2012]
4. **Lower Urinary Tract Obstruction (LUTO):** In cases of LUTO, urgent intervention is necessary. This involves bladder drainage via urethral catheter, medical stabilization of the neonate, and specific interventions like fulguration of PUV.
   In cases that do not involve LUTO, careful observation and sequential investigations using ultrasound and nuclear imaging are recommended. The decision for surgical intervention is based on evidence of structural obstruction to urine flow.
5. **Pelviureteric Junction Obstruction (PUJO):** Surgical treatment is indicated if there's gross pelvicalyceal dilatation with parenchymal thinning, obstructive excretory curve on nuclear renography, and a differential renal function of 10% or less on the affected side. Progressive pelvicalyceal dilatation on serial ultrasound and decreasing differential function on renography, along with symptoms like pain, hematuria, or recurrent infections, also indicate the need for pyeloplasty.
6. **Urinary Tract Infections (UTIs):** UTIs are managed medically. In cases of bladder dysfunction, comprehensive non-invasive and urodynamic studies are performed. Interventions like biofeedback, anticholinergic medications, alpha blockers, clean intermittent catheterization (CIC), and, rarely, bladder augmentation may be considered.

The approach to therapy depends on the specific diagnosis, severity of the condition, and the potential impact on renal function and overall health. Close monitoring, timely intervention, and individualized management plans are key in ensuring the best outcomes for infants and neonates with urinary tract abnormalities.

VI. CONCLUSION

Hydronephrosis occurs as a result of enlargement of the renal pelvis and/or calyces. When an infant is diagnosed with hydronephrosis before birth, the condition is known as prenatal hydronephrosis. Advances in prenatal imaging techniques have facilitated the early detection of urinary tract abnormalities, allowing healthcare providers to initiate appropriate interventions promptly. The grading systems, such as the APD grading system, Society of Fetal Urology (SFU) grading, and Urinary Tract Dilatation (UTD) classification, provide valuable tools for assessing the severity of hydronephrosis and guiding clinical decisions.

The journey of managing antenatal hydronephrosis involves a comprehensive approach, including antenatal assessment, postnatal evaluation, and therapeutic interventions tailored to the specific condition. The integration of various imaging modalities, such as ultrasound, magnetic resonance urography, and diuretic renography, ensures a thorough understanding of the anatomical and functional aspects of the urinary tract. This comprehensive assessment allows for the accurate identification of underlying causes, severity, and potential complications.

Therapeutic decisions are made upon severity of hydronephrosis and associated risk factors. Conditions like posterior urethral valves necessitate immediate operation, whereas moderate hydronephrosis may just necessitate watchful observation. Antibiotic prophylaxis and therapeutic intervention of urinary tract infections are critical parts of care for preventing complications and preserving renal function.

The medical community can provide a safe future for these infants by combining new diagnostic procedures, evidence-based guidelines, and individualised treatment regimens, with the objective of preserving renal function, reducing complications, and helping them to live healthy lives.

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