ORIGINAL ARTICLE

NEONATAL HYDRONEPHROSIS WITH REVIEW OF INITIAL ULTRASOUND IMAGING AND FOLLOW-UP PROTOCOLS

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ABSTRACT

BACKGROUND: Hydronephrosis is commonly detected during antenatal ultrasound (US) scans. Conflicting data exist concerning optimal timing for initial postnatal US and in scheduling follow up. **OBJECTIVE:** The aim of this work was to define the role of postnatal US in cases of antenatal hydronephrosis, and to settle a protocol for follow up. **METHODS:** This was a cross section observation study. We studied 212 patients (424 kidneys) with antenatal hydronephrosis. Abdominal ultrasound and color Doppler was performed. The greatest anterior-posterior diameter of the renal pelvis was measured in the transverse plan. Data analysis was performed using SPSS 17.0 Differences in clinical characteristics were tested by chi-square test. A *p* value <0.05 was considered statistically significant. **RESULTS:** 81.2% of kidneys were normal while 18.8% had hydronephrosis. Hydronephrosis was mild in 68.8%, moderate in 19.5% and severe in 11.7%, unilateral in 34.4% and bilateral in 65.6%, left sided more than right sided with the male to female ratio = 2:1 First US follow up showed improvement in 42.2%. Second US follow up was normal in 54.4% .Only 26 renal unites presented for third follow up. **CONCLUSION:** Investigation of mild/moderate hydronephrosis is better delayed 5-10 days until good urine flow is established.Severe hydronephrosis requires immediate imaging and further investigations. In neonates with prenatal dilatation and postnatal normal renal pelvis, one control scan during the fourth week of life is enough.All remaining uncomplicated hydronephrosis can be serially monitored with ultrasonography at 6 then 12 monthly intervals until resolution is documented.

Key words: ultrasound, hydronephrosis, prenatal, postnatal

Introduction

Hydronephrosis (HN) is a commonly detected renal abnormality during antenatal scans. There are multiple conflicting prognostic factors in the literature with no clear focus on the postnatal outcome. Conflicting data exist concerning optimal timing for initial post natal ultrasonography(US) in newborns with prenatal HN as well as in scheduling US follow up for those neonates.

The introduction of fetal US has allowed for the detection of many intrauterine anomalies.[1] Urological anomalies comprise 30-50% of all fetal abnormalities.[2] Of these, HN is the most common, comprising 50% of congenital malformation.[3] Fetal HN is found in 0.59%[4] to 1.4% of fetuses.[5] However, HN does not necessarily translate into obstruction. Moreover, many cases of neonatal HN improve or resolve spontaneously without surgical intervention.[4] The definition of mild or minimal pyelectasis in the literature is of questionable pathologic importance. Further, the outcome of fetuses with minimal pyelectasis is not all “benign” as suggested in some studies.[6] In fact, many such fetuses may require subsequent medical or surgical intervention. Thus, an anterior-posterior diameter equal to or greater than 4 mm or 7 mm before and after 33 weeks' gestation, respectively, warrants postnatal follow-up.[6] on the other hand, most clinicians consider a renal pelvis diameter (RPD) 6 mm late in gestation to be indicative of HN worthy of postnatal follow-up.[7] Seven mm

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at one month of age is the cutoff value of HN also in the study of Hideshi Miyakita, 2001.[8] The Australian Society for Ultrasound in Medicine defines HN according to gestation by anterior-posterior RPD 6 mm at 32 weeks is abnormal and 10 mm at any gestation is abnormal and needs post natal evaluation.[6] To standardize and categorize neonatal HN better, the Society of Fetal Urology (SFU) developed a gra-ding system based on the long-axis sonographic appearance of the renal parenchyma and pelvicalyceal system from 0 to IV. Only grades II Iand IV are thought to be clinically significant postnatally. Another des-cription of the degree of HN is the measurement of the maximum anterior-posterior diameter of the pelvis, or RPD. Normal = RPD 0:5 mm, mild HN = RPD 5:10 mm, moderate HN = RPD 10:15 mm and severe HN = RPD >15 mm.[1] These measures are accepted because Scott and Renwick,1988 estimated that a reference range of 0-5 mm would include about 95% of the population therefore, a diameter of more than 5 mm is relatively infrequent and may reflect at least transient disturbances in the fetal or neonatal urinary transport, which may contribute to the inconsistency of pyelectasis pre and postnatally.[9] Prenatal dilatation of urinary tract structures may be due to obstructive or non-obstructive causes, and it is known that 20 % of normal foetuses show some degree of renal pelvic dilatation on sonographic examination.[8] Transient and physiologic HN are the most common types (60%) that need US follow up. Other less common causes that may need medical or surgical intervention include vesico-ureteric reflux (VUR), posterior uretheral valve (PUV) and pelvi-ureteric junction obstruction (PUJ). Eighty percent of fetal HN is mild with 20% classified as moderate/severe.[4] Proper timing of the initial post natal ultrasound, the extent to which postnatal US follow up and other investigations of stable minimal/mild dilatation are required, the selected cases for further evaluation using VCUG and/ or renal isotope scan are debatable issues which should be clarified. The aim of this work is to define the exact role of US in the diagnosis and follow up of neonates presented with antenatal HN of different grades and to put a protocol for them.

Patients and Methods

Plan:
This was a cross section observation study.

Subjects:
Between January, 2010 and June, 2011, 212 patients referred to the pediatric US unit, Diagnostic radiology department, KAUH with antenatal HN were identified in our US database. Medical research ethical approval was obtained. The total number of kidneys studied was 424 kidneys. The study group included 140 (66%) males and 72 (34%) females ranging in age from one to 180 days (mean age 17.03 ± 25). All patients referred for follow up of different grades of renal pelvis dilatation discovered during antenatal scan. Exclusion criteria included cases of multicystic dysplastic kidneys (12 kidneys) and Polycystic kidney disease (2 kidneys) which were proved postnatally by US. So, the remaining number of kidneys included in the study was 410.

Methods:
Abdominal US was performed to all patients using Philips iU22 machine and a 5 - 7 MHz sector or semi sector transducers. Transverse and longitudinal images of each kidney were obtained. Color Doppler was used to differentiate vascular structures from dilated collecting system. The greatest anterior-posterior diameter of the renal pelvis was measured to the nearest 1 mm while the kidney was imaged in the transverse plan. Depending on the (SFU) classification of HN, RPD < 5 mm was considered to be normal, while from 5-10 mm was mild HN, from 10-15 mm was moderate HN and severe HN was diagnosed if the AP diameter of the renal pelvis was more than 15 mm. Follow up was required for a number of patients after variable duration. Follow up was done for one, two or three times. Results of follow up were analyzed into stationary, progressive or regressive course. VCUG was done for 59 patients to exclude PUV in cases of bilateral HN and hydroureter or to exclude isolated VUR. Renal isotope scan was done for 20 patients to detect obstructed non functioning kidneys.

Data analysis:
Data were collected and tabulated. Statistical Package for Social Science (SPSS) program version 17.0 was used for data analysis. Mean and standard deviation (SD) or median and interquartile range (IQR) were estimates of quantitative data while frequency and percentage were estimates of qualitative data. Differences in clinical characteristics were tested by chi-square test for qualitative data. A two-sided P value <0.05 was considered statistically significant.

Results

Considering number of renal units examined (410), 333 kidneys (81.2%) were normal at presentation, while 77 kidneys (18.8%) had different grades of HN with the p value = 0.000.Diagnosis and grading of HN was based upon the previous criteria mentioned in the patients and methods section. (Fig.1)

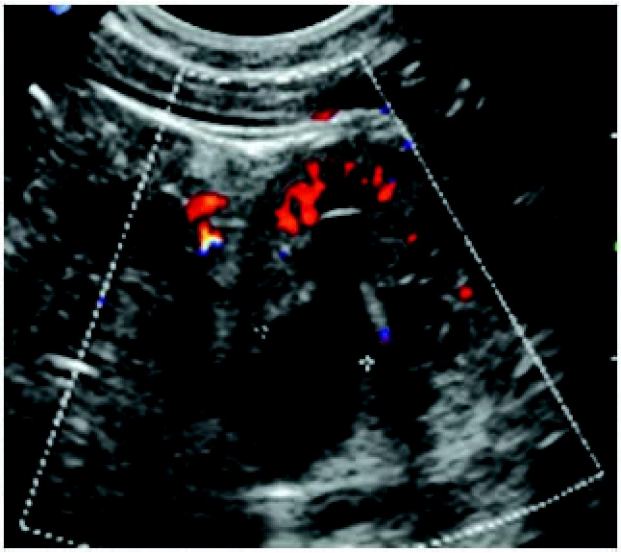

Figure1: Seven days-old neonate with mild left HN. Axial US & Doppler image showed RPD =9mm.

HN was mild in 53 renal units (68.8%), moderate in 15 renal units (19.5%), and severe in 9 renal units (11.7%).Table 1 shows distribution of different grades of HN among the right and left kidneys.

1st US	RT Pelvis N=205 N(%)	LT Pelvis N=219 N(%)
Normal (<5)	169 (82.4)	164 (74.9)
Mild HN	16 (7.8)	37 (16.9)
Moderate HN	9 (4.4)	7 (3.2)
Severe HN	0	8 (3.7)

Table 1: Distribution of HN grades among the right and left kidneys.

Neonatal HN was unilateral in 73 patients (34.4%) and bilateral in 139 (65.6%).left sided HN was found in 219 units and right sided in 205. In our study 140 patients (66%) were males, and 72 patients (33%) were females with the ratio 2:1.

First US follow up was requested to 173 renal units; 96 with renal pelvis<5mm, 53 with mild HN, 15 with moderate HN and 9 with severe HN. Most cases (42.2%) were improved while only 6.4% were stationary with abnormal measures (Tab. 2).

1st US FU US 1	Normal (n=96)	Mild (n=53)	Moderate/severe (n=24)	Pvalue
Within normal (n=56)	56 (58.3)	0	0	0.0001*
Improved (n=73)	29 (30.2)	33 (62.3)	11 (45.8)	
Progress (n=33)	11 (11.5)	12 (22.6)	10 (41.7)	
Stationary (n=11)	0	8 (15.1)	3 (12.5)	

Table 2: Distribution of cases subjected to first US follow up and its results.

Among 68 renal unites presented for second US follow up, most of them (56) showed normal measures, and only 11were stationary. (Tab. 3) showed the details.

1st US FU US 2	Normal (n=39)	Mild (n=22)	Moderate/severe (n=7)	Pvalue
Within normal (37)	30 (76.9)	6 (27.3)	1 (14.3)	0.000*
Improved (21)	8 (20.5)	9 (40.9)	4 (57.1)	
Progress (6)	0	6 (27.3)	0	
Stationary (4)	1 (2.6)	1 (4.5)	2 (28.6)	

Table 3: Distribution of cases subjected to second US follow up and its results.

Only 26 renal unites presented for third US follow up. Six cases were stationary. No worsening HN was detected (Tab. 4).

1st US FU US 3	Normal (n=20)	Mild (n=4)	Moderate (n=2)	Pvalue
Within normal	19 (95)	1 (25)	0	0.000*
Improved	1 (5)	3 (75)	2 (100)	

Table 4: Distribution of cases subjected to third US follow up and its results.

Most cases had normal calyces-mainly on the right side. The remaining cases showed different grades of dilatation; minimal, mild and moderate. Only one case showed severe right calyceal dilatation. (Tab. 5) showed distribution of calyceal dilatation on the right and left sides.

Calyces	RT	LT
	N (%)	N (%)
Normal	244 (95.3)	228 (89.1)
Minimal dilatation	3 (1.2)	11 (4.3)
Mild dilatation	4 (1.6)	9 (3.5)
Moderate dilatation	4 (1.6)	8 (3.1)
Severe dilatation	1 (0.4)	0

Table 5: Distribution of calyceal dilatation among the study group

Ureteric dilatation of different degrees was found in only 28 cases as shown in (Tab. 6).

Calyces	RT	LT
	N (%)	N (%)
Not dilated	249 (97.3)	235 (91.8)
Dilated	7 (2.7)	21 (8.2)

Table 6: Ureteric dilatation among the right and left kidneys.

Renal isotope scan was requested to 17 patients to detect renal function and obstructive HN. Seven cases (41%) were normal. Obstructive HN suggestive of PUJ was found in 6 cases (35%) (Fig.2), unilateral non functioning kidney in 2 cases (12%) and non obstructive HN in 2 cases (12%).

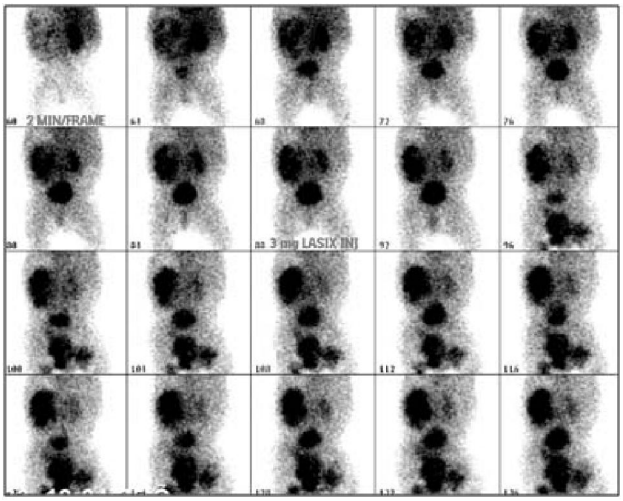

Figure 2: Neonate with severe left HN diagnosed by US. Renal isotope scan showed obstructed left kidney suggestive of PUJ obstruction.

VCUG was done for 55 patients. 47 (85.5%) were normal, 4 cases showed VUR of different grades (7.25%), 4 cases had PUV (7.25%) with either VUR G5 (in 2cases) (Fig.3), urinary bladder diverticulum (in1case) or isolated PUV (in1case).

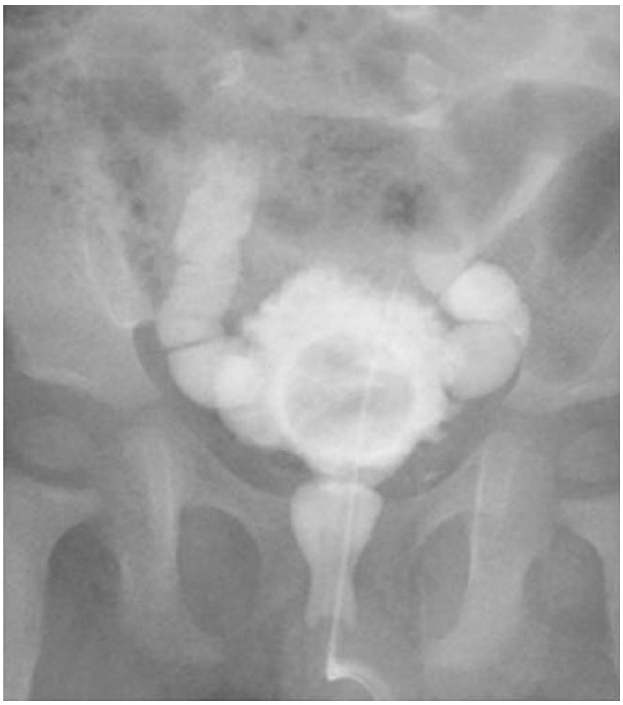

Figure 3: Male neonate with bilateral moderate HN diagnosed by US. VCUG in anterior-posterior view showed posterior uretheral valve with bilateral vesico-ureteric reflux.

Final diagnosis of the etiology of HN was reached in 14 cases based on US findings in addition to NM and VCUG (when done). (Tab. 7)

Diagnosis	Number	Percent
PUV + VUR	4	27.8
VUR unilateral/ bilateral	4	22.2
PUJ unilateral	6	33.3
Total	14	100

Table 7: Final diagnosis of 14 cases

Discussion

Antenatal ultrasound has been used for decades to detect fetal anomalies. Renal anomalies - in particular HN- is one of the most common fetal abnormalities that need post natal follow up. Moderate cases need scheduled follow up in addition to other imaging modalities e.g. VCUG and renal isotope scan. Severe cases often seek immediate medical or surgical consultation. The dilemma is usually in post natal management of minimal or mild HN where unnecessary

follow up or other investigations are usually done which exerts load on patients, their families and make abuse of imaging in the radiology department. Our results show that 81.2 % of cases are normal at presentation while only 18.8 % show different grades of HN. Finding normal renal pelvis in neonates with prenatal HN is common in many studies. Twenty-five percent[11] up to 61%[6] of cases with prenatal HN are normal after birth on post natal renal scan. These normal findings may contribute to transient physiologic changes that occur during pregnancy. In a study of Woodward M & Frank D 2002, transient physiologic HN account for approximately 60% of cases.[4] Several potential explanations exist for the common occurrence of RPD in the prenatal period. Pregnancy is associated with physiologic changes that are mediated by placental hormones. It has been shown that increases in maternal renal plasma flow and glomerular filtration rate occur.[11] The fetus is subjected to the same hormonal and physiologic milieu as the mother; therefore, the same factors leading to maternal HN may influence the fetal kidneys, leading to some degree of fetal HN that usually resolves after delivery. Our diagnosis of HN base on measuring the AP diameter of the renal pelvis in the axial images with the cutoff value is 5 mm. This measure is also followed by a study done at 2008 where it is stated that "Up to 5 mm of renal pelvis dilatation is normal on postnatal scan".[12] Although the initial literature in 1985 and 1986 defined 10 mm as the normal AP renal pelvis limit in transverse images.[13] recent publications have defined dimensions as small as 4 mm as evidence of dilatation.[6,14] The Society for Fetal Urology in 1993 stepped back from measurements to the more general terms of mild, moderate and severe dilatation.[15] There are now so many definitions in the radiological literature that it is no wonder so many children are investigated with additional imaging.[6,13,14,16] The modifiers of mild, moderate and severe are applied to kidneys with obstructive and nonobstructive HN.[17] Complicating the definition of dilatation of the urinary tract on US is the additional problem of its timing. The physiological dehydrated state of the neonate in the first 24 to 48 hours of life[2] up to 7days[18] as well as the decreased glomerular filtration rate, may result in a false-negative reading, showing no dilatation or less dilatation than would be documented on a later sonogram.[2] In the current study, 18.8 % of cases have HN. Mild HN is found in 68.8%%, moderate HN in 19.5% and severe HN in 11.7% of cases. HN is more on the left side. Left sided HN is found in 88% of the children in the study of Hideshi Miyakita, 2001. However, no explanation exists as to why the incidence of HN should be higher on the left side than on the right.[8] Our results match with many others in indicating the predominant susceptibility of boys to HN. In our study, male to female ratio is 2:1.[9,19] Many follow up US examinations are requested to a large number of neonates, including those whose renal pelvis is even < 5 mm at presentation. Most cases show either improved or stationary course while few percent of cases have progressive course. In the current study 1st follow up is done for 42% of cases. Most of them show normal measures, while only 19% have progressive HN. Normalized renal pelvis within few weeks after birth in the majority of cases is a common finding in many studies, suggesting that factors leading to transient pyelectaisis were overcome in these cases.[6,8] Although Up to 100% of mild HN cases are normalized within 2-12 months,[20] renal ultrasound is recommended for all infants to detect moderate progressive and severe cases that may need immediate intervention.[21] The magnitude of fetal renal pyelectasis doesn't correlate with post natal outcome. All fetal renal pelvises > or = 5 mm should be followed antenatally. Those foetuses with persistent pyelectasis should be evaluated after birth and followed until resolution of pyelectasis or until a diagnosis is obtained.[22] Although mild fetal HN appears to be associated with an excellent prognosis, however a small percent of cases may show progressive course during follow up. Various physiologic mechanisms may contribute to post natal pelvic widening. For example, maturation of the excretory function of the kidney and modifications of the relation anatomy between the renal pelvis and the ureter occurring with development could alter the function and shape of this system.[23] As mild fetal HN is associated with an excellent prognosis the extent of postnatal investigation is controversial. Some authors suggest that US combined with careful clinical review is all that is required.[2] Follow up of mild cases is advised after 1, 3, 12 months of age till it shows normal diameter.[6] Not all causes of neonatal HN are physiological. Obstructive causes are seen especially in progressive, moderate and severe cases.The problem in follow up is in cases with persistent moderate or progressive HN which may be due to obstructive aetiology such as PUJ and PUV, or non obstructive as VUR. In these cases further investigations are required. In our study, VUR is found in 4 HN cases -representing 7.25% of those subjected to VCUG. VUR isfound inup to 33% of cases of prenatal

HN in the study of Maizels M, 1994. These infant shave a high spontaneous resolutionrate.[17] Postnatal early diagnosis and appropriate management of VUR in infants with antenatal HN can prevent the occurrence of frequent UTIs, renal scaring and malnutrition, enabling normal growth and development.[24] PUV is an obstructive lesion usually suspected in cases with bilateral HN in addition to bladder outlet obstructive changes. Four cases-representing 7.25% of those subjected to VCUG- have PUV, two cases associated with VUR grade 5 and one case with bladder diverticulum. Another common cause of neonatal HN is significant PUJ obstruction which accounts for approximately 10% of prenatal HN. The HN is bilateral in up to 20-25% of cases.[4] The etiology in neonates is usually an intrinsic stenosis followed by a kink. It is usually suspected prenatally when there is HN with a very large renal pelvis (3 cm in A-P diameter), no ureteral dilation and normal bladder with normal amniotic fluid volume.[1] PUJ obstruction may resolve or progress over time, and requires US follow up. The likelihood of requiring surgical intervention with dilatation <15 mm is small, so even if PUJ is suggested on US, renal isotope are not routinely performed under 15 mm.[12] Nuclear medicine scanning may be used to quantitatively assess differential renal function, and it has become a primary study for defining PUJ obstruction. In most cases mercaptoacetyletriglycerine (MAG3) has replaced diethylenetriamine penta acetic acid (DTPA) as the radionuclide of choice. Because MAG3 is both filtered and secreted by the renal tubules, it is more useful in immature kidneys than is DTPA, which is filtered only by the glomerulus and is not actively secreted[25] MAG3 study can be done within 3-5 days of birth whereas DTPA is best delayed to 6 weeks of age when GFR is maximal. In the current study, 6 cases have severe dilatation with normal or minimally dilated calyces and normal ureters suspected of PUJ obstruction which is proved using renal isotope scan.The number of asymptomatic children evaluated in the neonatal period for prenatal HN is large and increasing. Subsequent additional imaging with voiding VCUG, renal scintigraphy, magnetic resonance imaging and excretory urography (IVP) is costly in time and effort, as well as anxiety producing for the parents and child. Occasionally, even after these additional tests have been interpreted as entirely normal, a child is followed with sonography for years with the sole finding of a subjective description on US of “mildly dilated collecting system.”[26] Further evaluation is recommended in those with sonographic findings of either caliceal dilatation or RPD measurement greater than 10 mm, or a combination of both findings. One must be careful to exclude vascular structures from the measurement.[26] In summary, based on our study and many previous studies[6,18,21] we recommend investigation of mild/ moderate HN is better delayed until good urine flow is established (5-10 days post delivery) but immediate scans are required in severe cases.[21] In neonates with prenatal dilatation and postnatal normal renal pelvis, one control scan during the fourth week of life to determine whether the postnatal scan had been false negative then, no further investigations should be done unless clinically indicated by the urologist.[6] All remaining uncomplicated HN can be serially monitored with US at 6 then 12 monthly intervals until resolution is documented.[21]

Conclusion

If a cutoff values that is use in classification of HN (> 5 mm) have been used while patient is first seen by US that would avoid multiple US visits and unnecessary follow up for normal and mild cases. In addition, following appropriate grading system will lead to wise direction of severe cases to further investigation, scheduled follow up of moderate and progressive.

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Conflict of Interest: None

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