

## Postnatal management of antenatally detected hydronephrosis

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**Author contributions:** Both the authors were involved in the collection of data, analyzing it, preparing the manuscript and revising it and have seen the final version of the article.

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Received: April 27, 2014 Revised: August 5, 2014

Accepted: August 27, 2014

Published online: November 24, 2014

### Abstract

With the increasing use of ultrasonography, congenital anomalies are often picked *in utero*. Antenatally detected hydronephrosis is amongst the most commonly detected abnormality. The management of this condition has raised considerable debate amongst clinicians dealing with it. This article is written with an idea to provide comprehensive information regarding the postnatal management of antenatally detected hydronephrosis. A detailed review of the current literature on this topic is provided. Also, guidelines have been given to facilitate the management of this condition.

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**Key words:** Antenatal hydronephrosis; Ultrasonography; Pelvi ureteric junction obstruction; Megaureter; Hydronephrosis; Multicystic dysplastic kidney

**Core tip:** This article provides practical guidelines for the postnatal management of antenatally detected hydronephrosis.

Sharma G, Sharma A. Postnatal management of antenatally detected hydronephrosis. *World J Clin Urol* 2014; 3(3): 283-294 Available from: URL: <http://www.wjgnet.com/2219-2816/full/v3/i3/283.htm> DOI: <http://dx.doi.org/10.5410/wjcu.v3.i3.283>

### INTRODUCTION

The detection of renal abnormalities during prenatal ultrasonography was first reported by Garrett *et al*<sup>[1]</sup> in 1970. Since then routine use of ultrasonography for detection of congenital anomalies has become a part of routine care during the antenatal period. Currently it is estimated that genitourinary anomalies comprise nearly 20% of all prenatally detected fetal anomalies<sup>[2]</sup>. Amongst these hydronephrosis is one of the most commonly detected anomalies seen in approximately 1% to 5% of all pregnancies and it occurs due to various causes<sup>[3]</sup> (Table 1). Thus we have an increasing number of patients who are presenting to the clinician with a presumptive diagnosis rather than a symptom and that too before they are born<sup>[4]</sup>. Logic dictates that this early detection should help in improving post natal outcomes and help in better preservation of the renal function. Lee *et al*<sup>[5]</sup> in their meta-analysis found that 12%-88% of these children will have demonstrable pathology depending on the degree of prenatally detected hydronephrosis. Hence a thorough postnatal evaluation of the upper and lower tracts is mandatory postnatally. But this also means that 88%-12% of these children will have no demonstrable pathology postnatally. This is borne out by various studies showing that the most common cause of antenatally detected hydronephrosis is transient or non obstructive dilatation of the pelvicalyceal system<sup>[6,7]</sup>. Thus, postnatally, the clinician is faced with dilemma to differentiate the hydronephrosis which will resolve spontaneously from the one which will become clinically significant and would need

**Table 1 Differential diagnosis of prenatal hydronephrosis**

Etiology	Incidence
Transient/physiologic	50%-70%
PUJ obstruction	10%-30%
Vesicoureteral reflux	10%-40%
Ureterovesical junction obstruction	5%-15%
Multicystic dysplastic kidney	2%-5%
Posterior urethral valves	1%-5%
Ureterocele	1%-5%
Others like ectopic ureter, <i>etc.</i>	< 1%

PUJ: Pelviureteric junction.

**Table 2 Descriptive definition of hydronephrosis by Antero Posterior Diameter**

Classification of hydronephrosis	Second trimester APD in mm	Third trimester APD in mm
Mild	4-7	7-9
Moderate	7-10	9-15
Severe	> 10	> 15

APD: Antero posterior diameter.

**Table 3 Society of fetal urology grading of hydronephrosis**

Grade 1	Urine barely splits the sinus
Grade 2	Moderate renal pelvis splitting confined to renal border with dilated major calyces
Grade 3	Pelvis distended outside the renal border, major and minor calyces are dilated; the parenchyma is spared
Grade 4	Parenchyma is thinned

surgery. This differentiation needs to be done by utilizing appropriate investigations using the lowest radiation and least invasive techniques so that timely surgical intervention can be done, in those who need it, to prevent renal function deterioration<sup>[4]</sup>. This article reviews the primary literature and consensus statements pertaining to antenatally detected hydronephrosis and sets forth our own recommendations regarding management of infants with this finding.

## DIAGNOSING HYDRONEPHROSIS ANTENATALLY

The diagnosis of fetal pelvis dilatation and its natural history postnatally is best understood if we understand that the definition of hydronephrosis has undergone a sea change. Traditionally hydronephrosis was defined as dilatation of the pelvicalyceal system due to partial or complete obstruction. Now clinicians understand that hydronephrosis is aseptic dilatation of the collecting system and it may or may not be associated with obstruction. Investigators have proposed that the term pyelectasis be used to describe dilatation of renal pelvis whereas pyelocaliectasis and hydronephrosis include dilatation of calyces. However, all these three terms are used inter-

changeably and are used to describe a dilated pelvicalyceal system regardless of its etiology<sup>[8]</sup>.

The antenatal ultrasound screening is most commonly performed at 18-20 wk of gestation. This is the time when the renal architecture becomes visibly distinct. Normally the renal pelvis and calyces are not seen, if seen then it indicates hydronephrosis. The sonologist should be vigilant in the antenatal period to differentiate a dilated collecting system from the hypoechoic sonolucent pyramids which may mimic hydronephrosis. Once the diagnosis of a dilated collecting system is made, it should be objectively described using one of the various classification systems. The majority of authors use either the Antero posterior diameter (APD) system or the Society of Fetal Urology (SFU) classification. With the sophisticated ultrasound machines with better resolution detecting smaller dilatations of the renal pelvis, the cut off value of the renal pelvis dilatation necessitating cognizance and achieving clinical significance has been a matter of debate. In the early 80's a threshold value of 10 mm indicated the need for further investigations in the post natal period<sup>[8]</sup>. In 1990, Mandell proposed a classification system based on APD and gestational age that helps to categorize antenatal hydronephrosis in the mild, moderate and severe variety<sup>[9]</sup>. This was further substantiated by the work of Corteville *et al*<sup>[10]</sup> and should now be taken as a standard classification of antenatal hydronephrosis based on APD<sup>[11,12]</sup>. A number of other studies have noted persistent postnatal uropathy when the APD measures > 6 mm at < 20 wk, > 8 mm at 20-30 wk and > 10 mm at > 30 wk gestation<sup>[13,14]</sup>. Recently cut off of 6 mm at 20 wk and 10 mm at 30 wk have been suggested for pyelectasis and an APD cut off of 10 mm at 20 wk and 12 mm at 30 wk for hydronephrosis<sup>[15]</sup>. An interesting feature of this study has been the effort to separate pyelectasis from hydronephrosis so that postnatal ultrasound can be avoided in a number of patients. However given the subjective nature of sonography and the factors like maternal hydration affecting the measurements, this issue has not been resolved as of today and hence clinicians should follow a standard classification and grade the dilatation as mild, moderate and severe as suggested in Table 2.

Another classification used to describe hydronephrosis is the Society of Fetal Urology classification which was first described in 1993<sup>[16]</sup>. This system describes the renal pelvis dilatation along with the dilatation of the calyces and hence its effect on the parenchyma (Table 3). However this grading system is not universally followed and due to the ambiguity in inter and intra observer agreement especially in grade 3 and grade 4 hydronephrosis, modifications have been proposed<sup>[17,18]</sup>. Even these modifications have not gained universal acceptance.

Given these discrepancies, it is imperative that worldwide a uniform system of classifying and grading hydronephrosis should be followed. In order to overcome these variations and negate the effect of hydration and full bladder, group from Hong Kong has proposed a Hy-

dronephrosis Index and have given nomograms to help clinicians judge the degree of renal pelvic dilatation based on the gestational age<sup>[19]</sup>. The hydronephrosis index is defined by the APD of the fetal kidney divided by the urinary bladder volume. It is an interesting index but its clinical usefulness and specificity in fetuses with abnormally dilated renal pelvis or gross hydronephrosis is not established.

Till a reliable method is described, which overcomes the variables of maternal hydration, bladder fullness of fetuses and the operator dependency, clinicians should mention the method used to diagnose antenatal hydronephrosis and grade its findings. If the APD is used than the presence or absence of associated calyceal dilatation should also be mentioned.

## OTHER FINDINGS

Besides the diagnosis of hydronephrosis, the antenatal ultrasonography should document the amniotic fluid level, degree of urinary bladder distension; its emptying and wall thickness visualization of ureter, presence of normal or any abnormality in the opposite kidney and the echogenicity of the kidneys. These additional findings often contribute to establishing the postnatal diagnosis<sup>[20]</sup>. In cases of posterior urethral valves the level of amniotic fluid is a significant predictor of renal function and clinical outcome<sup>[21]</sup>.

## TIMING AND FREQUENCY OF ANTENATAL ULTRASOUND

Currently, there is no agreed upon protocol for the antenatal evaluation and its follow up. The first anomaly scan is done usually between 18-20 wk, this should reliably diagnose antenatal hydronephrosis. The subsequent frequency of follow up ultrasound is often based on the severity of findings and the pathology suspected. There is usually no added advantage of doing very frequent ultrasound examinations for it adds very little to the diagnosis and subsequent management and only aggravates parental anxiety. Once the diagnosis is made then the next ultrasonography can be done in the third trimester between 28-32 wk. However more frequent ultrasounds, every 4-6 wk, will be needed in cases having bilateral hydronephrosis, posterior urethral valves, prune belly syndrome and severe hydronephrosis in a solitary kidney. Ultrasound findings in these clinical scenarios have an important bearing on the decision making in deciding the obstetric course of the patient.

## ANTENATAL COUNSELLING

Once the diagnosis of ante natal hydronephrosis (ANH) is made, the parents are engulfed by a myriad of emotions. The two important things that the clinician is often asked to answer is-Should antenatal intervention be done and what happens postnatally. Addressing the parental

anxiety and concerns is as important as the clinical management of the child.

### **Prenatal intervention**

Studies have shown that urinary obstruction can cause renal dysplasia and relief of that obstruction can prevent dysplasia if performed early enough<sup>[22]</sup>. The goal of fetal intervention would be to relieve this obstruction and allow for normal renal development. This in turn would maintain the amniotic fluid levels to allow for normal lung development. Currently, fetal intervention is recommended for those with documented lower tract obstruction, the commonest and most widely studied being posterior urethral valves, where intervention would significantly benefit the overall fetal (and its renal function) prognosis. Open fetal surgery, vesico-amniotic shunt, renal pelvis aspiration, vesico-centesis, fetoscopic fulguration of posterior urethral valves etc have been tried. Though this sounds fascinating, its attendant problems and risks cannot be overlooked. Also does it alter the prognosis significantly and does the benefit outweigh the risks should be evaluated diligently.

At present fetal intervention is indicated in cases where the life of the fetus is at risk, typically a second trimester fetus with significant oligohydramnios, suspected good renal function and absence of other life threatening anomalies<sup>[21]</sup>. However, this is often too late to prevent renal dysplasia. The procedure is associated with significant risk of infection and also significant fetal and maternal morbidity and fetal mortality<sup>[23,24]</sup>. Thus, except in a select few cases fetal intervention should not be done and even these cases should be done in centres where the necessary expertise and experience is available.

### **What happens postnatally?**

When the diagnosis of ANH is made the parents often have apprehension that the child will need surgery postnatally<sup>[25]</sup>. They need to be assured and often a session of counseling with the pediatric urologist who will be taking care of the child postnatally goes a long way to allay the apprehensions of the parents. What should be emphasized that though there is no cause for alarm in majority of cases, a proper and rigorous follow up is a norm in majority of the cases.

## POST NATAL MANAGEMENT

“A perfection of means but a confusion of conclusion seems to be our problem-Albert Einstein”. There is no ambiguity regarding that all antenatally detected hydronephrosis should be evaluated by an ultrasound postnatally<sup>[5]</sup> (Level I evidence Grade A recommendation). Since infants are relatively dehydrated at birth, the initial postnatal ultrasonography should be performed after 48 h of birth. Day two of life is preferred to enable adequate hydration after delivery but circumstances pertaining to early discharge following delivery may not allow this. Also breast fed neonates may not be adequately

**Table 4 Measures to be taken within first 48 h after birth in infants diagnosed with antenatal hydronephrosis**

USG	Suspected lower tract obstruction, <i>e.g.</i> , Posterior urethral valves, prune belly syndrome Bilateral hydronephrosis with or without hydroureter Solitary kidney with APD > 15 mm or SFU grade 2 or more
Antibiotic prophylaxis	Suspected lower tract obstruction APD > 10 mm or SFU grade 2 or more in the third trimester Solitary kidney with hydronephrosis of any grade Bilateral hydronephrosis
VCUG	Suspected posterior urethral valves antenatally
Catheterization	Suspected lower tract obstruction-posterior urethral valve or prune belly syndrome

VCUG: Voiding cysto urethrogram; APD: Antero Posterior Diameter; SFU: Society of Fetal Urology; USG: Ultrasonography.

hydrated until a steady milk flow is established. Hence the first postnatal ultrasound is preferably done between 5-7 d after birth<sup>[12,26,27]</sup>. The exceptions to this caveat are: (1) Suspected lower tract obstruction *e.g.*, Posterior urethral valves; (2) Severe bilateral hydronephrosis with or without hydroureter; and (3) Solitary kidney with hydronephrosis especially if the APD is > 15 mm or it is SFU grade 2 or more in the third trimester. Early sonography in these situations has obvious bearing on further management.

### SHOULD CHEMOPROPHYLAXIS BE STARTED IMMEDIATE POSTNATALLY?

Whenever there is hydronephrosis the treating clinician is worried about two things—obstruction and infection. The obstruction needs to be established in most cases with ANH. However the clinician is worried about the possibility of infection in a dilated system with stasis of urine. So, should neonates and infants with ANH be put on antibiotic prophylaxis? Till date there are no prospective studies providing level I evidence to support the use of prophylaxis. The available literature is conflicting. Studies have shown that the risk of infection increases with the degree of hydronephrosis<sup>[28-31]</sup>. Coelho *et al*<sup>[28]</sup> found the incidence of urinary tract infection (UTI) to be 10% for those with mild hydronephrosis, 20% for those with moderate and 40% for those with severe hydronephrosis. Girls appear to be at greater risk than boys<sup>[29]</sup>. However these studies are observational in nature and not standardized as regards, the method of urine collection, definition of infection, selection of patients for voiding cystourethrogram and use of prophylactic antibiotics.

More and more data is coming regarding the limited usefulness of prophylactic antibiotics and with the varying practice patterns due to variations in geographic location, clinician experience and above all variable health care practices in developing countries, as of yet, no standardized uniform guidelines have been proposed. However undeniably patients with mild hydronephrosis are

at much less risk of infection as compared to those with moderate to severe hydronephrosis<sup>[12,32-36]</sup>. If prophylaxis is started then the choice of antibiotics are Amoxicillin (15 mg/kg) or Cephalexin (2 mg/kg). Based on the available evidence we propose the following to be done within the first 48 h after birth in neonates born with antenatally diagnosed hydronephrosis (Table 4).

### ULTRASOUND AT 5-7 D AFTER BIRTH

All infants detected to have ANH should be evaluated by a postnatal ultrasound, which is usually done at 5-7 d after birth<sup>[11,37]</sup> (for the reasons described above). The following should be the aim of doing this evaluation using a tool which is easily available, provides good anatomical information, is non invasive and is not associated with any radiation: (1) Confirm the presence of hydronephrosis; (2) Grade the degree of hydronephrosis; (3) Plan further tests and evaluation and management strategies based on the ultrasound findings; and (4) Decide the need for antibiotic prophylaxis.

The ultrasonography should be done with the baby being well fed. It is the practice of one of the authors (Sharma A) to start the examination of these babies by scanning the bladder first. If the bladder is full, usually the baby voids and the degree of bladder emptying is known immediately giving a fair idea regarding the absence of outflow obstruction. Also once the bladder is empty, the effect of a distended bladder on the filling and emptying of the collecting system resulting in fallacious diagnosis of pyelectasis is avoided. The mechanism by which a full bladder causes dilatation of the renal pelvis and the maximal degree of normal dilatation is not known. However it is accepted that when urinary bladder is distended than false positive cases may occur<sup>[19]</sup>. Hence if a sonologist sees mild degree of hydronephrosis than whether it persists or disappears after bladder emptying should be looked for and mentioned in the report.

Ultrasonography at 5-7 d would show one of the following scenarios: (1) No hydronephrosis-Normal pelvicalyceal system; (2) Unilateral hydronephrosis; (3) Bilateral hydronephrosis; (4) Unilateral Hydronephrosis with hydroureter; and (5) Bilateral hydronephrosis with bilateral hydroureter. Let us see each scenario and discuss its management.

### NO HYDRONEPHROSIS-NORMAL KIDNEYS

Postnatal ultrasound will be normal in 41%-88% of cases diagnosed to have hydronephrosis antenatally<sup>[10,11,38]</sup>. Why this happens is a matter of speculation. Constantinou<sup>[39]</sup> suggested that a pacemaker in the renal pelvis activates the smooth muscle of the renal pelvis to initiate peristaltic contractions. The direction of the peristalsis is from the renal calyces and pelvis towards the urinary bladder. Any immaturity of the pacemaker in the renal

**Table 5 Management recommendations in neonates with antenatal hydronephrosis but Normal Post natal ultrasound**

USG	At 1 mo and at 3-6 mo
VCUG	Not recommended if two USG are normal
Antibiotic prophylaxis	Not recommended routinely Would be prudent to be started if the follow up is not reliable For those not getting prophylaxis, parents should be told to get a urine routine if the neonate shows any signs of not being well

VCUG: Voiding cysto urethrogram; USG: Ultrasonography.

pelvis might lead to poor co-ordination of the peristaltic activity<sup>[40-42]</sup>. Thus there is impediment of the emptying of the renal pelvis resulting in urinary stasis in the renal pelvis. Also, disco-ordination of muscle cell excitation can spread in any direction so that retrograde peristalsis can occur<sup>[43]</sup>. It has been speculated by Leung *et al*<sup>[19]</sup> that the pacemaker in the renal pelvis does not mature at an early gestational age. Maturation of this pacemaker and ureteral peristalsis starts around 28 wk of gestation, after which equilibrium is gradually established between pelvicalyceal filling and bladder filling/emptying in the fetus. This probably explains the disappearing fetal hydronephrosis postnatally when the physiological function of the urinary tract becomes more mature.

Even if the first postnatal scan does not show hydronephrosis a repeat scan at 3-6 mo is mandatory. If the scans, on both occasions, do not show hydronephrosis, than a diagnosis of transient hydronephrosis can be safely and surely made. Emphasizing the need for a second scan is of paramount importance as late worsening or recurrent hydronephrosis is seen in nearly 15% of infants<sup>[44-46]</sup>.

These infants have a 25% incidence of associated vesico ureteral reflux (VUR)<sup>[47]</sup>. Hence some investigators have proposed antibiotic prophylaxis and a Voiding Cysto Urethrogram (VCUG) study in these patients<sup>[48-51]</sup>. The objections to VCUG being performed in all cases has been based on the feeling that it is not an entirely benign procedure due to its invasive nature, radiation exposure, expense and up to 15% rate of post procedure urinary tract infection<sup>[52]</sup>. Also majority of the VUR in this category of patients would be low grade with a high chance of resolution of spontaneously. Ismaili *et al*<sup>[53]</sup> found that if two successive ultrasonography were normal than VCUG was not justified. Two recent studies have also shown that routine VCUG and antibiotic prophylaxis are not to be recommended in these patients who are at low risk of infection<sup>[6,54,55]</sup>. But as those cases where the follow up is unlikely to be very rigorous and methodical as occurs in the low socio economic group especially in developing countries, advising prophylactic antibiotics would be a natural extension of the logic to make attempts to prevent renal damage.

We propose the following recommendations based on the presently available literature in this category of patients (Table 5).

## UNILATERAL HYDRONEPHROSIS BUT NO HYDROURETER

This constitutes the largest category of patients with prenatally detected hydronephrosis. 50%-70% of these would have transient or physiologic hydronephrosis which regresses over a period of time and has no clinical implications; pelviureteric Junction (PUJ) obstruction accounts for the remaining 30%-50% of cases<sup>[56,57]</sup>.

The following questions need to be addressed when these patients are being evaluated: (1) When and how to evaluate them initially? (2) How to do follow up? (3) When to do a functional study? (4) How to differentiate non obstructed from obstructed systems? (5) How long to follow them? and (6) When to Intervene?

### When and how to evaluate Initially?

There is no ambiguity regarding the fact the first evaluation should be on the 5<sup>th</sup> to 7<sup>th</sup> day after birth and is by ultrasound. However the agreement ends here. How to grade hydronephrosis has been a matter of much debate. The landmark study by Dhillon *et al*<sup>[58]</sup> in 1998, proposed the measurement of APD of the renal pelvis as a means of judging the severity of hydronephrosis and predicting the need for surgery. While the APD measurement provides an objective means of predicting pathology, many felt that other features are also important in determining the severity of hydronephrosis. Therefore, features such as calyceal dilatation and parenchymal thinning should also be considered in grading the severity of hydronephrosis. These factors were taken into account by the Society of Fetal Urology and a grading system for hydronephrosis was proposed<sup>[3]</sup>. This is a five point severity stratification system which also helps in predicting the need for surgical intervention<sup>[59]</sup>. Although SFU is a useful system, two alternative grading systems have been proposed. Sibai *et al*<sup>[60]</sup> proposed sub classifying SFU grade 4 into Grade 4 A-with segmental cortical thinning and Grade 4 B-diffuse cortical thinning. Onen<sup>[61]</sup> proposed subcategorizing patients with SFU grade 4 into those kidneys with mild to moderate *vs* severe parenchymal compromise to account for the underestimation of disease severity in patients with intra renal pelvic configuration.

Whatever system is followed, after the first postnatal ultrasound, the clinician should be able to categorize these patients in the mild, moderate and severe hydronephrosis categories so that further management can be decided<sup>[12]</sup>. The categorization of this category of patients in Mild, Moderate and Severe types, based on APD and SFU grading is given in Table 6. After the Initial Ultrasound at 5-7 d after birth the next follow up ultrasound should be done at 4 wk.

### How to follow up?

The important questions to be answered during follow up of these infants are: (1) Do they need prophylactic antibiotics; (2) Do they need VCUG; and (3) When to

**Table 6** Categorization of patients with unilateral hydronephrosis with no hydroureter into mild, moderate and severe hydronephrosis based on Antero Posterior Diameter /Society of Fetal Urology Grading

	Mild	Moderate	Severe
APD	< 20 mm	20-30 mm	> 30 mm
SFU	Grade 1 and 2	Grade 3	Grade 4

APD: Antero posterior diameter; SFU: Society of Fetal Urology.

repeat ultrasound?

**Do they need prophylactic antibiotics**

Regardless of gender prophylactic antibiotics are not recommended for patients with mild degree of hydronephrosis because of the low risk of developing a urinary tract infection or need for subsequent surgery<sup>[6,28,35]</sup>. But chemoprophylaxis is indicated in those with moderate or severe degree of hydronephrosis till VCUG is done.

**Do they need VCUG**

Patients with mild degree of hydronephrosis do not need VCUG. Though a small subset will have associated VUR, majority of the times it is a low grade VUR which subsides on its own<sup>[47]</sup>. However those with moderate to severe hydronephrosis need a VCUG. VUR would be diagnosed in about 20% of these patients<sup>[62,63]</sup>.

The timing of VCUG in this group of patients should be at 4-6 wk. These patients are on prophylactic antibiotics, hence to diagnose or rule out VUR, it would be prudent to wait till the neonate is old enough. Whether it should be a conventional VCUG or a radionuclide cystogram is a matter of personal preference and debate. A conventional VCUG would not only diagnose lower grade of VUR but would also exclude the possibility of posterior urethral valve, which can present indolently<sup>[64]</sup>.

It is recommended that if no reflux is seen then chemoprophylaxis can be stopped unless it is a solitary kidney (to avoid the slightest chance of infection affecting a solitary renal unit). In those with VUR chemoprophylaxis should be continued<sup>[12,65]</sup>.

**When to repeat ultrasound?**

Irrespective of the grade of hydronephrosis a repeat ultrasound is warranted at 4 wk after birth. It confirms the severity of hydronephrosis and also gives an insight into progression/regression of hydronephrosis. Also the hydronephrosis can be categorized into mild, moderate and severe type again. Changes in the severity of hydronephrosis can occur as kidneys mature and/or signs of obstruction manifest<sup>[12]</sup>.

If there is mild hydronephrosis (APD < 20 mm or SFU Grade 1 or 2) and for moderate hydronephrosis (APD 20-30 mm or SFU Grade 3)-confirmed at 1 mo a repeat ultrasound is indicated at 3 mo and then six monthly till the age of 3 years and then yearly till the age of six years. Whenever the sonography shows resolution

of hydronephrosis a repeat ultrasonography at 3-6 mo is warranted to confirm the finding as recurrence is noted in previously resolved hydronephrosis<sup>[34]</sup>.

For severe grade of hydronephrosis (APD > 30 mm or SFU Grade 4)-ultrasound at 1 mo confirms the findings and then further sonography is done based on the need for intervention. If conservative management is opted (in cases with differential function > 40%) then ultrasonography should be done at monthly intervals for 3 mo, then bimonthly till the age of 1 year. Any sign of increasing hydronephrosis would warrant intervention or a further radionuclide study to determine the need for intervention.

**When to do a functional study?**

A diuretic renogram is indicated in those with severe degree of hydronephrosis at 4 wk after birth. All other patients can be followed with ultrasound as mentioned above, with a radionuclide study done when there are signs of increasing hydronephrosis. The functional evaluation should be by mercapto acetyl triglycine (MAG3) or ethyl cysteine (EC) Renogram using a F-15 or F0 protocol. Due to lack of maturity of the kidneys and a very high background activity resulting in erroneous calculation of differential function a DTPA renogram should be avoided in the first 6 mo of life<sup>[66-68]</sup>.

**How long to follow them?**

If there is no increasing hydronephrosis on serial ultrasounds then also the child needs to be followed up till the age of 6 years. A stable dilated system at 6 years would not warrant further study except around puberty when it would be worthwhile having a look at the kidneys by ultrasound to rule out any deterioration of hydronephrosis with the spurt in growth that occurs. This area, where the dilatation has stabilized in the early childhood, has hitherto not been investigated thoroughly and further studies are awaited to look into the fate of those kidneys later in life. A radionuclide study at 6 years, before stopping follow up, would be useful to confirm the good functional status of the kidney and establish a baseline value for further comparison in future.

**When to intervene?**

Patients with unilateral hydronephrosis is the category where the clinician faces the biggest dilemma of differentiating a non obstructed dilated system, where hydronephrosis will regress spontaneously over a period of time (or remain stable) from a dilated but obstructed system. This needs to be diagnosed as early as possible so that intervention can be done before renal damage occurs. The dilemma gains much significance as the clinician has to choose between conservative approach *vs* surgery. Till an answer to this dilemma is obtained, there is much parental anxiety, as the need for surgery hangs like a sword of Damocles on the head of the patient.

Two modalities have been extensively studied to provide an answer to this vexing question-Ultrasonography

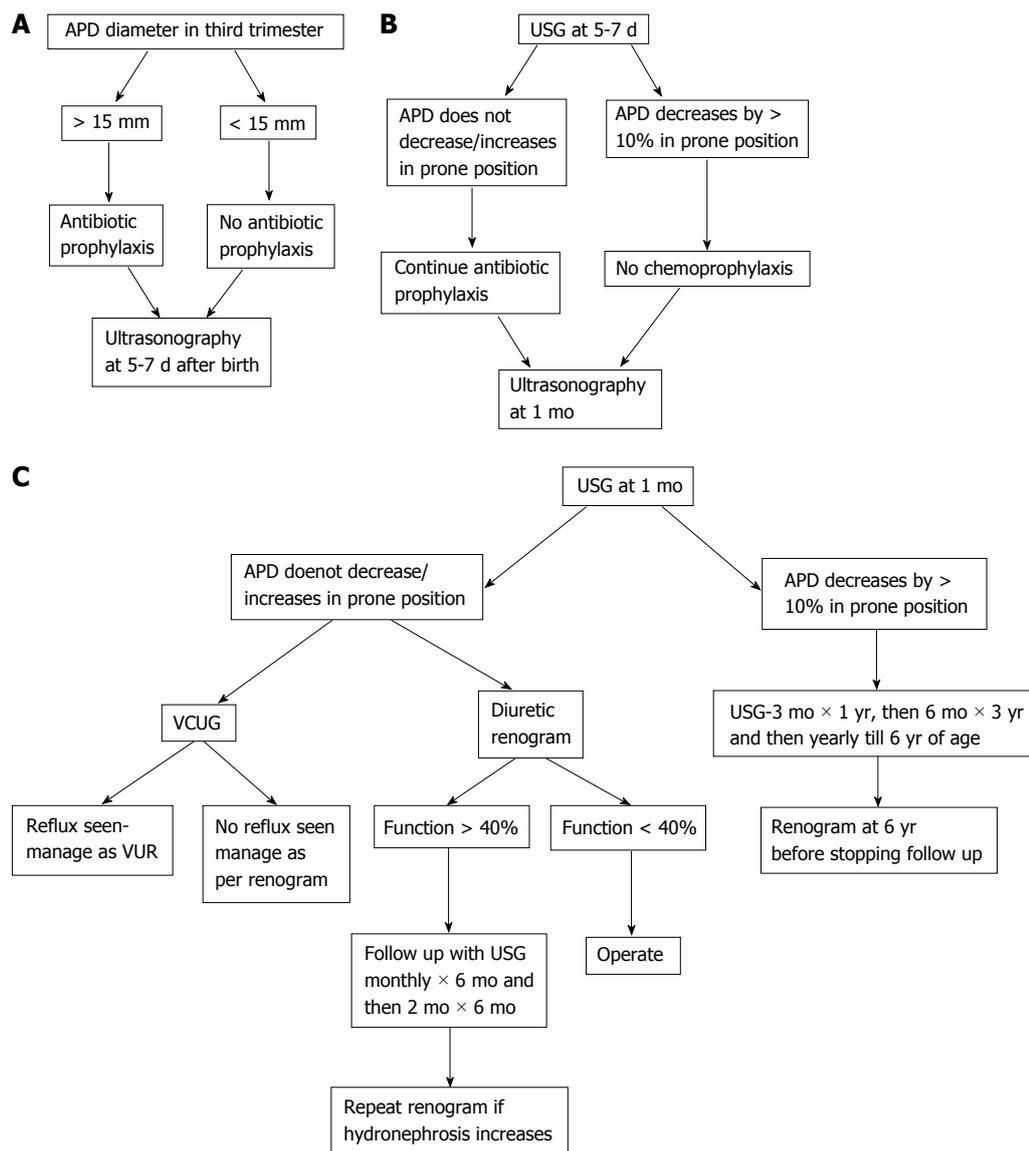
and Radionuclide studies. Though a diuretic renogram has been considered the gold standard to diagnose obstruction, numbers of studies have questioned its ability, especially in the way it is done at present, to diagnose obstruction and more importantly diagnose cases which will need surgical intervention. Hafez *et al*<sup>[69]</sup> in 2002 had shown that drainage curves from the initial renogram are not always predictive of cases which need surgical intervention. For many years the output function (drainage) has been empirically estimated on the basis of the slope of the frusemide curve, a T half > 15-20 min reflecting an obstruction and a short T half excluding obstruction<sup>[70]</sup>. This method is still largely used by many urologists. Of course a good renal emptying practically excludes any significant risk factor related to obstruction; but what should be the conclusion when the T half is high? If the function has been compromised then the diagnosis of obstruction is beyond doubt. But can the diagnosis of obstruction be made based on the curve pattern in the presence of well preserved renal function, the answer is probably not. The major pitfall in this interpretation is what has been called the “reservoir function”. When there is a dilated system, the tracer, even under the influence of frusemide has to fill the renal pelvis before leaving the kidney, even if there is no significant restriction to urinary flow. Thus, despite all technical precautions, one can end up the test with no or limited renal pelvis emptying, simply due to this reservoir effect<sup>[66-68]</sup>. It is therefore not acceptable to conclude that the kidney is obstructed simply because of poor drainage. It has been shown during longitudinal conservative follow up of these children that the drainage might improve considerably and spontaneously, sometimes after several years<sup>[71]</sup>. Newer parameters like output efficiency and Normalized Residual Activity have been evaluated and are found to be more reliable<sup>[66-68]</sup>. However they have not gained universal acceptance and also their values have not been standardized. Two new parameters which have shown promise in differentiating an obstructed from a non obstructed system are-Post micturition and post erect images acquired 1 h after tracer injection<sup>[66-68]</sup> and the cortical transit time<sup>[72,73]</sup>. The post micturition post erect images taken at 60 min showing retained tracer are more indicative of poor drainage and obstruction than the post frusemide curves. They can be taken easily and even an infant can be held in the arms of the parent to obtain the post erect images. However this also has not been incorporated in routine diuretic renogram all over the world.

Cortical Transit time has shown promise to identify those renal units which are at risk of deterioration of renal function due to obstruction. It is the passage of the tracer from the outer cortex to the inner structures *i.e.*, the medulla and collecting system. In a normal kidney one expects a rapid transit with more or less homogenous kidney filling in about 2 min. A delay in this suggests obstruction. It has also been found that kidneys with delayed cortical transit times are not only at high risk of deterioration of renal function, but also show good post

operative improvement in 80% of cases<sup>[72,73]</sup>. However, 20%-30% of these kidneys would not show good recovery of function. Also a large prospective study is needed to confirm that cortical transit time is the best predictor of which children should be operated upon<sup>[67,68]</sup>. Till one of these parameters are universally accepted, the current practice of getting a well tempered renogram, lacking sensitivity and specificity, serves only to get the differential renal function and is a poor man's Di Mercapto Succinic Acid Scan<sup>[36,74]</sup>. The decision to operate is simple when the differential renal function is < 40%. But the dilemma persists in kidneys with function > 40%.

It is imperative to make this differentiation between a dilated but non obstructed system from an obstructed system at an optimum period of time as delay in this can lead to irreversible damage to the obstructed kidneys and intervention later may not lead to partial/complete recovery of the lost function. When the differential function is > 40%, the infant is under observation. Ultrasound is the most universally accepted, non invasive and non ionizing tool used to evaluate these children during this period of observation. Investigators have studied whether ultrasonography can be used to predict the need for surgery. Dhillon<sup>[58]</sup>, from the Great Ormond street group was the first to describe the predictive value of anteroposterior diameter of the renal pelvis for determining the need for pyeloplasty. This landmark study found that amongst those with an APD > 40 mm, 80% needed surgery; while those with an APD between 30-40 mm; 55% needed surgery and no intervention was needed in those with an APD < 12 mm. However, mere APD cannot definitively predict the need for surgery as a good number of patients with an APD between 20-40 mm did not need surgery. Burgu *et al*<sup>[75]</sup> also found that an APD of, 20 mm correlated with persistence of differential renal function and that stable or decreased APD on serial imaging was also predictive of retained or improved function. Other investigators have used renal parenchymal area, calyx to parenchymal ratio and pelvis cortex ratio and hydronephrosis index to evaluate the hydronephrosis postnatally and predict the need for surgery<sup>[76,77]</sup>. However these parameters have not found widespread acceptance.

Recently, an interesting observation has been published by Sharma *et al*<sup>[78]</sup>, demonstrating the utility of comparing APD measurements in patients with unilateral hydronephrosis in supine and prone positions. They found that in those cases where the APD decreases in prone position by > 10% as compared to supine position, the hydronephrosis decreases over a period of time or does not increase, resulting in preserved differential function. These cases did not need surgery. In contrast, if the APD does not change in prone position or increases in prone position then these cases needed surgical intervention as their differential function showed a substantial drop<sup>[78]</sup>. This small study of 39 patients from a single center is based on the simple principle that the pelvicalyceal system drains better in prone position, hence the obstructed systems would not show better drainage and



**Figure 1** Proposed management plan for patients with Unilateral Hydronephrosis with no hydroureter (A-C). APD: Antero Posterior Diameter; VCUG: Voiding cysto urethrogram; USG: Ultrasonography; VUR: Vesico ureteral reflux.

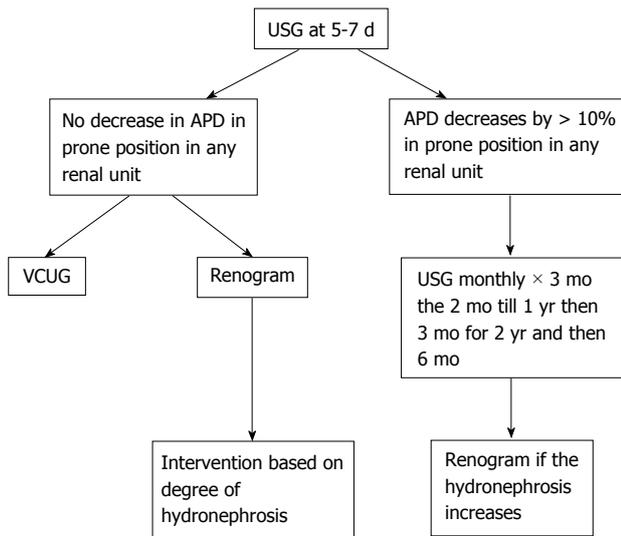
the APD would remain the same or increase in prone position as the urine from the different calyces pools in the pelvis. If it is a dilated but non obstructed system that in the dependent prone position there would be better drainage and the APD would decrease in prone position as compared to supine position. These measurements of course would have to be done with an empty bladder as a full bladder interferes with the drainage from the pelvicalyceal system. At present, this seems to be the simplest way of differentiating a dilated but non obstructed system from a dilated and obstructed system. Also, variables like the degree of hydration would not affect the conclusion drawn.

The aim of evaluation by noninvasive and inexpensive modality like ultrasonography is to diagnose those patients at risk of deterioration of renal function, differentiate them from those who would do well in the long run and help in judiciously utilizing renogram to intervene at

the optimum moment before renal function is affected. We propose the following algorithm to manage these patients with unilateral hydronephrosis (Figure 1).

## BILATERAL HYDRONEPHROSIS

Infants with bilateral hydronephrosis are at an increased risk of infection compared to children with unilateral hydronephrosis. The risk of renal function deterioration is high in this group<sup>[36]</sup>. In this group of patients difference in differential function on renogram is not a reliable way of predicting the need for surgery as both the renal units may have deterioration of function which would not be reflected in the percentage difference in function. Literature is sparse in providing guidelines to manage this group of patients. We propose the following algorithm to manage these patients (Figure 2). This logical proposal is based on the literature available for unilateral hydrone-



**Figure 2** Management of patients with bilateral hydronephrosis with no hydroureter. APD: Antero Posterior Diameter; VCUG: Voiding cysto urethro-gram; USG: Ultrasonography.

phrosis and needs to be substantiated by a larger multi-center study.

## UNILATERAL HYDRONEPHROSIS WITH UNILATERAL HYDROURETER

This is the group of patients who has a megaureter, the nature of which needs to be ascertained. Literature in this group of patients is quite clear regarding the following points in their management: (1) Definition of megaureter-retrovesical ureteric diameter  $> 7$  mm from 30 wk gestation onwards is taken as megaureter<sup>[79]</sup>; (2) Antibiotic prophylaxis-is recommended for the first 6-12 mo of life<sup>[80,81]</sup> as the risk of UTI is higher with uretero vesical junction obstruction than with PUJ obstruction; (3) VCUG-an early VCUG is recommended as 14% of these patients may have an associated posterior urethral valves<sup>[82]</sup>. VCUG not only would rule out bladder outflow obstruction but also would confirm or rule out reflux and thus define further course of management; (4) Renogram-based on the data from Great Ormond Street a Diuretic renogram is indicated using MAG3 or EC in patients with ureteric dilatation  $> 10$  mm<sup>[83]</sup>; and (5) Defining obstruction-Interpretation of renogram in the presence of a dilated ureter may be difficult, as delayed transit may be caused by an increased capacity of the dilated ureter and pelvis. Poor drainage is also apparent because the bladder is full and the effect of gravity is incomplete<sup>[84]</sup>. For these reasons interpretation of the wash out curves should be made in the light of differential renal function and the degree of renal pelvis dilatation. An initial differential renal function of  $< 40\%$  or a drop in function by  $> 5\%$  on serial scans is taken as significant. On the other hand delayed transit on diuretic renogram in the presence of stable or improving dilatation and a differential function above 40% in an asymptomatic

patient are not strong indicators of obstruction. A close follow up with serial ultrasounds is recommended in this group<sup>[85]</sup>.

## BILATERAL HYDRONEPHROSIS WITH BILATERAL HYDROURETER

Most of these cases are associated with Bladder outflow obstruction and/or bilateral reflux. The following recommendations are just an extension of the rationale thinking based on the now standardized protocol in the management of unilateral hydronephrosis with hydroureter: (1) Antibiotic prophylaxis-recommended; (2) VCUG-to be done at the earliest under antibiotic cover to confirm or rule out posterior urethral valves; (3) Renogram-to be done using MAG3 or EC within the first 4 wk of life, in cases of bilateral megaureter(not refluxing and not associated with posterior urethral valves); and (4) Definition of obstruction-Differential renal function should be interpreted in clinical context, since values within normal range will be seen when there is bilateral renal damage and/or in the presence of chronic renal failure.

## CONCLUSION

Postnatal management of prenatally detected hydronephrosis is a topic which has evoked widespread interest. The issue which remains ambiguous at present and is the area of much study and research is how to differentiate a dilated but non obstructed system from a dilated and obstructed system. The utilization of sonography and the acceptance of parameters like output efficiency normalized residual activity and cortical transit time on renogram would be able to provide definitive answers to this dilemma in the near future.

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