Taiwanese Journal of Obstetrics & Gynecology 54 (2015) 554–558

Contents lists available at ScienceDirect

Taiwanese Journal of Obstetrics & Gynecology

journal homepage: www.tjog-online.com

Original Article

Frequency of postnatal hydronephrosis in infants with a renal anterior–posterior pelvic diameter > 4 mm on midtrimester ultrasound

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ARTICLE INFO

Article history:
Accepted 6 February 2015

Keywords:
antenatal diagnosis
fetal hydronephrosis
renal pelvic diameter
ultrasound

ABSTRACT

Objective: To examine the association of antenatal renal pelvic dilatation observed on midtrimester ultrasound screening with the presence of hydronephrosis in newborn infants.
Materials and methods: The records of patients who received fetal ultrasound examination at 18–28 weeks' gestation from May 2008 to March 2012 were retrospectively reviewed. A fetal renal pelvic anterior–posterior (AP) diameter > 4 mm was considered abnormal and ≤ 4 mm was considered normal. On postnatal ultrasound, a renal pelvic AP diameter > 3 mm was considered to indicate hydronephrosis and ≤ 3 mm was considered normal. The association of postnatal hydronephrosis with prenatal pelvic AP diameter was determined using binary logistic regression analysis.
Results: The study comprised 1310 newborn infants: 684 (52.2%) male and 626 (47.8%) female. Multivariate analysis showed a right or left prenatal AP renal pelvic diameter > 4 mm was associated with a higher risk of postnatal hydronephrosis compared with a right and left prenatal AP renal pelvic diameter ≤ 4 mm. Boys had a higher risk for postnatal hydronephrosis than girls (odds ratio = 2.42, $p < 0.05$).
Conclusion: An antenatal renal pelvic AP diameter > 4 mm on midtrimester ultrasound is predictive of postnatal hydronephrosis.

Introduction

Dilatation of the fetal renal pelvis is the most commonly detected abnormality on antenatal ultrasound, and is reported to occur in 0.6–4.3% of pregnancies [1,2]. The diagnosis of renal pelvic dilatation (hydronephrosis) is based on an increased anterior–posterior (AP) diameter of the renal pelvis, and criteria are dependent on gestational age [3]. Antenatal hydronephrosis is present if the renal pelvic AP diameter is ≥ 4 mm in the second trimester and ≥ 7 mm in the third trimester [3].

Fetal hydronephrosis can result from a number of conditions including pelvic or vesicoureteral junction obstruction, vesicoureteral reflux, posterior urethral valves, pelvic–ureteric junction obstruction, and other rare congenital anomalies [4]. A renal pelvic AP diameter > 15 mm is strongly associated with pathology of the urinary tract that requires treatment after birth [5–11]. However, in the majority of cases, the renal pelvis is mildly or moderately dilated and no cause is identified [9–12]. In those cases, dilatation of the fetal renal pelvis may resolve spontaneously with no long-term complications [9–12].

There is no clear consensus on the follow up and management of mild or moderate hydronephrosis observed on antenatal ultrasound, although it is generally recommended that a postnatal evaluation be performed if the AP diameter of the renal pelvis exceeds 10 mm at any point in gestation [13]. Although a number of predictive algorithms have been developed, some studies have indicated that mild hydronephrosis that resolves during the course of a pregnancy may reoccur and progress, ultimately requiring

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http://dx.doi.org/10.1016/j.tjog.2015.08.007

treatment [14–16]. Thus, determining the occurrence of postnatal hydronephrosis based on the presence of antenatal renal pelvic dilatation may aid in identifying neonates in which an evaluation for causes of hydronephrosis is warranted.

The purpose of this study was to examine the association of antenatal renal pelvic dilatation observed on midtrimester ultrasound screening with the presence of hydronephrosis in newborn infants.

Patients and methods

We retrospectively reviewed the records of patients who received a fetal ultrasound examination at 18–28 weeks' gestation at Cathay General Hospital (Taipei, Taiwan) from May 2008 to March 2012. Patients were excluded from the analysis if a fetal or chromosomal anomaly (e.g., Down syndrome) was present, the pregnancy ended in an intrauterine fetal demise, pregnancy outcome was not available, or the newborn did not receive renal ultrasound. Twin pregnancies were included in the study, and the two fetuses were recorded individually. This study was approved by the Institutional Review Board, and because of the retrospective nature, the requirement for informed patient consent was waived.

Prenatal ultrasound examinations were performed by two trained physicians with a Philips iu22c5-1 ultrasound device (5656 AE, Eindhoven, The Netherlands) using a standard protocol [11]. The diameter of the renal pelvis was routinely measured as part of this scan. Postnatal ultrasound examinations were performed by an experienced ultrasound technician using an HP M2410A ultrasound device (USA) with a 5–7.2-Hz transducer. When prenatal hydronephrosis was diagnosed, infants received an ultrasound examination after birth.

Data extracted from the medical records included maternal age and gestational age when the prenatal ultrasound was performed, prenatal fetal ultrasound measurements and left and right renal pelvic AP diameters, birth data, and neonatal ultrasound left and right renal pelvic AP diameters. A fetal left or right renal pelvic AP diameter > 4 mm determined by ultrasound was considered abnormal (hydronephrosis) and a diameter ≤ 4 mm was considered normal. A renal pelvic AP diameter of 4–6 mm, 7–10 mm, and > 10 mm was considered mild, moderate, or severe hydronephrosis, respectively [3]. On postnatal ultrasound, a left or right renal pelvic AP diameter > 3 mm was considered to indicate the presence of hydronephrosis, and a diameter ≤ 3 mm was considered normal [3]. Representative pre- and postnatal renal ultrasound is shown in Figure 1.

Statistical analysis

Categorical data were presented as *n* (%) and continuous data as mean ± standard deviation. The association of postnatal hydronephrosis with prenatal left and right renal pelvic AP diameters was determined using binary logistic regression analysis, and results were presented as odds ratio (OR) with corresponding 95% confidence interval (CI), and *p* value. All statistical assessments were two-tailed and a value of $p < 0.05$ was considered statistically significant. Statistical analyses were performed using SPSS version 15.0 statistics software (SPSS Inc., Chicago, IL, USA).

Results

A total of 3159 women received midtrimester ultrasound examinations at Cathay General Hospital, Taiwan, between May 2008 and March 2012. One hundred and sixty-six fetuses had renal pelvic dilatation ≥ 4 mm and 2993 did not have dilatation. A total of 1310 patients with complete demographic and clinical data were included in this study. The data of 22 patients excluded from the analysis due to Down syndrome, trisomy 18, termination, or intrauterine fetal demise are shown in Table S1. In these 22 patients, there were two cases with a prenatal renal pelvic diameter > 4 mm: the patient with Chart Number 9 had a right renal pelvic diameter of 5.3 mm and the patient with Chart Number 71 had a left renal pelvic diameter of 6.95 mm.

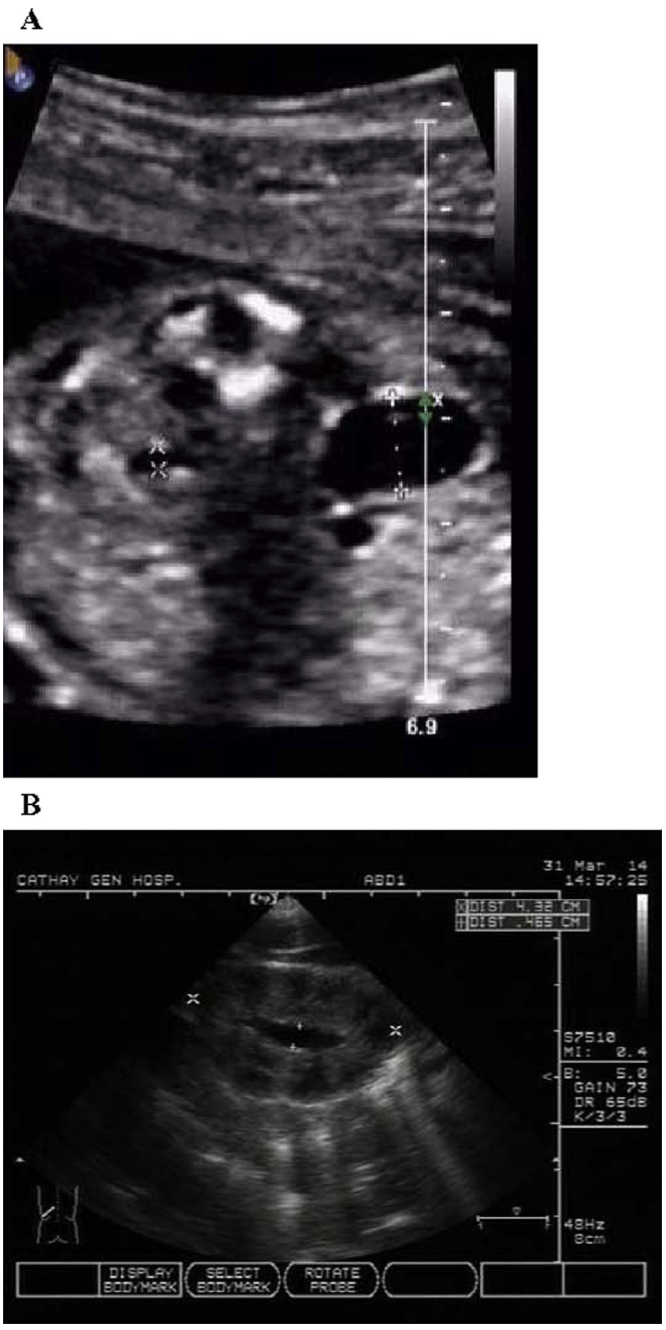

Figure 1. Representative figures of: (A) prenatal fetal ultrasound showing a fetus with hydronephrosis, and a transverse view of bilateral kidneys with the fetus in the prone position; and (B) postnatal ultrasound measurement of anterior–posterior renal pelvis diameter. Longitudinal view of one kidney. The renal pelvic diameter measured from the inner border of the anterior side of the renal pelvis to the inner border of the posterior side was > 3 mm.

Maternal and neonatal characteristics of the 1310 included patients are summarized in Table 1. Maternal age ranged from 21 years to 46 years, and there were 684 (52.2%) male and 626 (47.8%) female neonates. As measured on prenatal ultrasound, 43 neonates

Table 1
Patient characteristics.

Variables	$N = 1310$
Maternal age (y)	33.42 ± 3.71
Fetal position	
Breech	444 (33.9)
Transverse	88 (6.7)
Vertex	778 (59.4)
Fetal sex	
Male	684 (52.2)
Female	626 (47.8)
Gestational weeks at prenatal ultrasound	22.99 ± 1.38
Estimated fetal weight (g)	713.12 ± 141.06
Biparietal diameter (mm)	56.85 ± 4.784
Fetal abdominal circumference (mm)	183.27 ± 16.74
Prenatal AP renal pelvic diameter, left[a]	
≤ 4 mm	1266 (96.7)
>4 mm	43 (3.3)
Prenatal AP renal pelvic diameter, right[a]	
≤4 mm	1273 (97.2)
>4 mm	36 (2.8)
Postnatal AP renal pelvic diameter, left[a]	
≤3 mm	1149 (89.3)
>3 mm	137 (10.7)
Postnatal AP renal pelvic diameter, right[a]	
≤ 3 mm	1200 (93.4)
>3 mm	85 (6.6)
Postnatal hydronephrosis[a,b]	
Left ≤ 3 mm; right ≤ 3 mm	1109 (86.3)
Left > 3 mm; right ≤ 3 mm	91 (7.1)
Left ≤ 3 mm; right > 3 mm	40 (3.1)
Left >3 mm; right > 3 mm	45 (3.5)
Level of hydronephrosis (postpartum record)	
Normal	1130 (86.3)
Mild	170 (13.0)
Moderate	9 (0.7)
Sever	1 (0.1)

Data are presented as mean ± standard deviation or *n* (%).
AP = anterior–posterior.
[a] One patient had missing prenatal left kidney data, 25 patients had missing postnatal left kidney data, and 26 patients had missing right kidney data.
[b] Patients with postnatal AP diameter of the right or left kidney > 3 mm were defined as having hydronephrosis.

(3.3%) had a left renal pelvic AP diameter > 4 mm and 36 (2.8%) had a right renal pelvic diameter > 4 mm. Postnatally, 137 (10.7%) newborns had a left renal pelvic AP diameter > 3 mm, 85 (6.6%) had a right renal pelvic AP diameter > 3 mm, and in 45 (3.5%) neonates, the left and right renal pelvic diameters were both > 3 mm. Overall, 1130 (86.3%) neonates did not have hydronephrosis, 170 (13%) had mild hydronephrosis, nine (0.7%) had moderate hydronephrosis, and one (0.1%) had severe hydronephrosis. The prenatal and postnatal renal AP diameters of the kidneys and the frequency of hydronephrosis were similar among the different years (all, $p > 0.05$; Table 1).

Analyses of the association of postnatal hydronephrosis with prenatal AP renal pelvic diameter with and without adjusting for sex are shown in Table 2. Univariate analysis showed a right or left prenatal AP renal pelvic diameter > 4 mm was associated with a higher risk of postnatal hydronephrosis compared with a right and left prenatal AP renal pelvic diameter ≤ 4 mm (OR = 3.97 for left prenatal AP renal pelvic diameter > 4 mm, OR = 8.72 for right prenatal AP renal pelvic diameter > 4 mm, and OR = 14.54 for both right and left prenatal AP renal pelvic diameters > 4 mm; all, $p < 0.05$). Similar associations were found on multivariate analysis (OR = 3.07 for left prenatal AP renal pelvic diameter > 4 mm, OR = 9.85 for right prenatal AP renal pelvic diameter > 4 mm, and OR = 12.95 for both right and left prenatal AP renal pelvic diameters > 4 mm; all, $p < 0.05$).

Fetal sex was not associated with prenatal AP renal pelvic diameter, but was associated with the postnatal hydronephrosis (Tables S2 and S3). Male neonates had a higher risk for postnatal hydronephrosis than females (OR = 2.42, $p < 0.05$).

Discussion

The results of this study showed that a right or left prenatal AP renal pelvic diameter > 4 mm was associated with a higher risk of postnatal hydronephrosis compared with a right and left prenatal AP renal pelvic diameter ≤ 4 mm, and male neonates were at higher risk of postnatal hydronephrosis than females. Based on these results, when fetal hydronephrosis (renal pelvic AP diameter > 4 mm) is present, we recommend renal sonography after delivery. Although most cases [59.6% (31/52)] will resolve after delivery, assurance should be given. By contrast, 11.9% (149/1254) of fetuses with a normal midtrimester prenatal examination will develop postnatal hydronephrosis after delivery. We believe this is important information when consulting women receiving midtrimester sonography. We suggest follow up when the AP diameter is 4–7 mm, and antibiotic administration when it is > 7 mm; however, the number of cases > 7 mm was limited in this study.

Renal pelvic dilatation is commonly seen on antenatal ultrasound and its management remains a clinical dilemma. Although it is clear that severe antenatal hydronephrosis requires postnatal evaluation, there is no clear consensus on the follow up and management of mild or moderate hydronephrosis observed on antenatal ultrasound [17–20]. The postnatal evaluation of fetal hydronephrosis may be invasive and lengthy [8,9]. Thus, the risks and inconvenience of a protracted evaluation need to be weighed against the probability that milder degrees of renal pelvic dilatation will resolve without resulting in renal damage [18]. Predictive algorithms, although clinically useful for helping to decide which cases do not require an extensive work-up, may miss some cases in which surgical management may be needed [3,16].

Table 2
Association of postnatal hydronephrosis with prenatal AP renal pelvic diameter ($n = 1284$ patients).[a]

Prenatal AP renal pelvic diameter	Postnatal hydronephrosis[b]		Univariate		Multivariate	
	Present ($n = 177$)	Absent ($n = 1107$)	OR (95% CI)[c]	*p*	Adjusted OR (95% CI)[d]	*p*
Left ≤ 4 mm; right ≤ 4 mm	149 (12.1)	1083 (87.9)	1		1	
Left > 4 mm; right ≤ 4 mm	6 (35.3)	11 (64.7)	3.97 (1.45–10.88)	0.007*	3.07 (1.11–8.50)	0.031*
Left ≤ 4 mm; right > 4 mm	6 (54.5)	5 (45.5)	8.72 (2.63–28.93)	< 0.001*	9.85 (2.89–33.59)	< 0.001*
Left > 4 mm; right > 4 mm	16 (66.7)	8 (33.3)	14.54 (6.12–34.55)	< 0.001*	12.95 (5.37–31.21)	< 0.001*

* $p < 0.05$ indicates significant difference.
AP = anterior–posterior; CI = confidence interval; OR = odds ratio.
[a] One patient had missing prenatal left kidney data, 25 patients had missing postnatal left kidney data, and 26 patients had missing right kidney data.
[b] Data are summarized as *n* (%). Patients with postnatal AP diameter of the right or left kidney > 3 mm were defined as having hydronephrosis.
[c] OR and 95% CI of OR were derived using binary logistic regression analysis.
[d] Adjusted OR and 95% CI were derived using binary logistic regression analysis adjusting for sex.

Many studies have examined outcomes of antenatally diagnosed renal pelvic dilatation. Gökaslan et al [8] reported that the spontaneous resolution of mild hydronephrosis was significantly greater than that of severe hydronephrosis (64% vs. 29%, respectively). Shamshirsaz et al [21] examined fetal renal pelvic diameters determined by ultrasound with respect to predicting the need for subsequent postnatal surgery and found that a second trimester renal AP diameter of 9.5 mm had a sensitivity of 71% and specificity of 81%, and a third trimester value of 15.0 mm had a sensitivity of 85% and a specificity of 94% for predicting the need for postnatal surgery. Duin et al [22] studied 764 fetuses with renal pelvic dilatation and reported that a renal pelvic AP diameter $\geq$ 5 mm in the second and/or third trimester was better able to detect uropathy and conditions that required surgery compared with an AP diameter of $\geq$ 10 mm, but exhibited similar results as a diameter of $\geq$ 7 mm in the third trimester (Cortville criteria). Al-Shibli et al [17] classified renal pelvic dilatation as normal (< 5 mm), moderate (10–15 mm), and severe (> 15 mm) and found that severe required a comprehensive postnatal evaluation, moderate was associated with uropathy, but surgical intervention was rarely necessary, and mild was unlikely to be associated with any significant uropathy.

Few studies have examined the association of fetal renal pelvic dilatation with subsequent renal function in the newborn. Kim et al [23] reported that fetal renal pelvic dilatation was associated with renal differential function; 16% of fetuses with dilatation had $\leq$ 35% differential function after birth than unaffected fetuses.

Vesicoureteral reflux is a common cause of antenatal renal pelvic dilatation and postnatal hydronephrosis. Phan et al [24] studied 111 infants with isolated antenatal renal pelvic dilatation and reported that 15% had vesicoureteral reflux and that a large proportion of these infants had a normal postnatal ultrasound or only mild postnatal renal pelvic dilatation. They also reported that voiding cystourethrography was the only reliable test for detecting vesicoureteral reflux postnatally. Dias et al [25] reported that fetal or postnatal renal pelvic dilatation alone were poor predictors of vesicoureteral reflux; however, when the results of both tests < 10 mm were considered negative indicators of moderate to severe vesicoureteral reflux the sensitivity for the diagnosis reached 97%. Hothi et al [18] performed a systematic review and meta-analysis of cohort studies of fetuses with a renal pelvic diameter $\leq$ 15 mm that included 18 reports and found that the OR for postnatal renal pelvic dilatation doubled per millimeter increase in the fetal renal pelvic diameter, and the risks of obstruction and vesicoureteral reflux were lower with lower values of dilatation. Grazioli et al [26] found that although an antenatal renal pelvic AP diameter $\geq$ 5 mm was not predictive of vesicoureteral reflux, a postnatal AP diameter of 7 mm was predictive of vesicoureteral reflux and a cut-off of 10 mm was diagnostic of all cases in which voiding cystourethrography revealed vesicoureteral reflux.

Ultrasound is the primary method for diagnosing renal pelvic dilatation antenatally and postnatally. However, Pereira et al [27] studied intra- and interobserver variability of ultrasound measurements of the renal pelvis and classification of hydronephrosis severity and found that although inter- and intraobserver measurement errors were low, and the agreement to hydronephrosis diagnosis and classification was only fair. The authors concluded that serial ultrasound examinations are preferable for making a diagnosis of hydronephrosis. Some authors have advocated postnatal serial ultrasound examinations in combination with dynamic evaluation of the urinary tract during voiding to evaluate a finding of mild fetal hydronephrosis [28].

There were strengths and limitations to this study. The strengths of this study were the large sample size and that no similar studies have been performed with Taiwanese patients. In addition, investigations of this nature are rare. The study, however, was limited by its retrospective nature and by missing data of some patients. In addition, the absence of postnatal ultrasound for a large number of patients, because they did not deliver at the study hospital, markedly reduced the number of infants included in the analysis. Lastly, follow up of the infants with hydronephrosis was not conducted.

Conclusion

A right or left prenatal AP renal pelvic diameter > 4 mm is associated with a higher risk of postnatal hydronephrosis compared with a right and left prenatal AP renal pelvic diameter $\leq$ 4 mm, and male neonates are at higher risk of postnatal hydronephrosis than females. These results can assist in determining appropriate follow up and evaluation of fetuses found to have renal pelvic dilatation.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.tjog.2015.08.007.

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