

Subject Area:

## The role of routine abdominal ultrasound in newborns for detection of renal abnormalities

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# The role of routine abdominal ultrasound in newborns for detection of renal abnormalities

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## Abstract

### Introduction

Congenital and acquired renal diseases, which can produce renal insufficiency during the neonatal period, may be classified according to their ultrasonographic (US) characteristics: increased parenchymal echogenicity (renal parenchymal diseases, angiotensin-converting enzyme inhibitor fetopathy, and cortical necrosis), cystic disease (glomerulocystic kidney disease, autosomal recessive polycystic renal disease, multicystic dysplastic kidney, and cystic renal dysplasia), obstructive uropathies (ureteropelvic junction obstruction and posterior urethral valves), infections (candidal infections), and renal agenesis. The high-resolution sector and linear-array transducers allow the characterization of the underlying pathologic conditions in many cases. Findings of the renal parenchymal disease will vary on Doppler US, and during the acute phase, diastolic flow can be decreased, absent, or reversed. In patients with glomerulocystic kidney disease, US shows bilaterally enlarged kidneys with diffusely increased echogenicity and retention of a reniform contour, loss of corticomedullary differentiation, and cortical cysts. Obstruction of the ureteropelvic junction, the most common cause of hydronephrosis in neonates, can be seen on US as a dilated renal pelvis with dilated and communicating calices, lack of dilatation in the distal portion of the ureter, changes of renal dysplasia with increased echogenicity of the renal parenchyma, and parenchymal cysts, depending on the severity and duration of the obstruction. The high-resolution US provides an improved characterization of the renal parenchyma and a more precise description of renal architecture. The aim of this work was to evaluate the benefit of routinely performing an abdominal ultrasound on newborns to detect possible renal abnormalities, which may be missed antenatally.

### Patients and methods

This was a longitudinal study of 200 consecutive apparently normal neonates at Damietta University Hospital. The authors performed an abdominal ultrasound on newborns to detect possible renal abnormalities.

### Results

In this study, the incidence of renal abnormality was found in 23 (11.5%) neonates; most abnormalities were found in males (78.3%). Moreover, the majority of abnormalities were seen in a young age group less than 20 days. In this study, regarding the ultrasound abnormality findings, three (13%) neonates had left hydronephrosis G II, with left pelviureteric junction obstruction, two (8.7%) neonates had bilateral hydronephrosis with right pelviureteric junction obstruction, two (8.7%) neonates had left multicystic dysplastic kidney and left mild nephropathy, two (8.7%) neonates had an ectopic kidney, two (8.7%) neonates had an enlarged kidney, two (8.7%) neonates had right mild multicystic dysplastic kidney and left mild hydronephrosis, and two (8.7%) neonates had right mild hydronephrosis and dilated right ureter, with right vesicoureteric reflex. There was a statistically significant difference between positive cases of ultrasound abnormality and the sex of the newborn. There was a significant statistical relation between positive cases of ultrasound abnormality and the age of the newborn.

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**Conclusion**

This study has been able to demonstrate an 11.5% incidence of various types of urinary anomalies in this sample.

**Keywords:** Ectopic kidney, hydronephrosis, neonate, pelviureteric

**INTRODUCTION**

Congenital renal diseases are commonly encountered in ultrasound imaging studies. The clinical presentation, along with ultrasound imaging features and vascularity, as assessed by Doppler ultrasonography (US), helps inaccurate diagnosis. Despite dramatic improvements in MRI, computed tomography, and nuclear study, sonography continues to occupy a central role in the evaluation and detection of congenital renal diseases owing to its advantage of rapid scanning time, lack of radiation exposure, cost-effectiveness, and easy feasibility [1].

Abnormalities of the kidneys and urinary tract are the most common abnormalities detected during routine antenatal ultrasound imaging. Over the past decade, recommendations for postnatal evaluation of these abnormalities have been under intense scrutiny. Large cohort studies have resulted in significant changes to the current standard of care. This review focuses on the most commonly detected antenatal renal abnormalities and the current recommendations for postnatal evaluation [2].

The utility of US in the evaluation of abnormal neonatal kidneys has been described for hydronephrosis, dysplastic kidneys, and renal vein thrombosis. US is being utilized with increasing frequency to evaluate renal disease in infants with compromised renal function, decreased urine output, hypertension, abdominal masses, or congenital anomalies [1].

There are conflicting reports on the optimal time to perform a postnatal abdominal scan for urological abnormalities after birth. Proponents of delaying scan till 72 h after birth suggest that earlier scans may be misleading owing to relative oliguria in the first 72 h of life, which may lead to underestimation of the degree of hydronephrosis [3].

However, other studies have not corroborated this claim, and it is technically more convenient to perform the scans before the mother and neonate are discharged home, usually within 48 h after birth, as was done in this study. The default cases who failed to keep their follow-up visits also suggest that predischarge scans are more desirable in the study area [4].

This work aimed to evaluate the benefit of routinely performing an abdominal ultrasound on newborns to detecting possible renal abnormalities, which may be missed antenatally.

**PATIENTS AND METHODS****Patients**

Ethics committee approval was taken. This was a longitudinal study of 200 consecutive apparently normal neonates at Damietta University Hospital.

**Inclusion criteria**

Full-term apparently normal neonates of both sexes in the neonatal period were included.

**Exclusion criteria**

The following were the exclusion criteria:

- (1) An infant with apparent congenital anomalies.
- (2) An infant with feature suggestive of chromosomal abnormalities.
- (3) An infant with manifestation suggestive renal disease.
- (4) An infant with evidence of renal anomalies that was known antenatally.

**Methods**

All patients was subjected to the following:

- (1) Taking a full history: this included age, sex, and anthropometric measurements.
- (2) Examination:
  - (a) General examination: a routine clinical examination was performed on all the newborns to exclude any obvious congenital abnormality.
  - (b) Local examination: an abdominal examination was performed on all the newborns.
- (3) Abdominal ultrasound: a 3–5 MHz sector or linear transducer is used to scan the urinary tract. Although no specific preparation is required for scanning the kidneys, fasting optimizes the visualization. Evaluation of the renal vessels is augmented by adequate patient hydration. Additional recent software advances, including compound imaging and speckle reduction, may increase lesion conspicuity and decrease artifacts. The US was performed before the mother and child were discharged, usually within the first 5 days of life.

The kidneys are scanned in the transverse and coronal planes. Optimal patient positioning varies; supine and lateral decubitus positions often suffice, although oblique and occasionally prone positioning may be necessary. Usually, a combination of subcostal and intercostal approaches is required to evaluate the kidneys fully; the upper pole of the left kidney may be particularly difficult to image without a combination of approaches. Varying the degree of respiration can help in the complete evaluation of kidneys.

The scans were done at the mother's bedside using a FUJIFILM SonoSite, Inc. 21919 30<sup>th</sup> Drive SE (Bothell, Washington 98021-3904 United States) portable US machine with Doppler facilities. All scans were performed by the consultant radiologist. A curvilinear transducer with a frequency range of 5–7.5 MHz was used on the neonates

following the application of a water-based, nonallergenic ultrasound.

## RESULTS

This study was carried out on 200 consecutive apparently normal neonates at Damietta University Hospital.

Table 1 shows the distribution of the studied neonatal regarding their age. Age from 15 to 21 days was higher with 60 (30%) neonates, followed by age from 8 to 14 days and age from 22 to 48 days with the same numbers at 52 (26%) neonates, and age from 1 to 7 days represented 36 (18%) neonates.

Table 2 shows the distribution of the studied neonatal regarding their sex. Of the 200 (100%) cases, neonatal males were higher with 118 (59%), and females were 82 (41%).

Table 3 shows the anthropometric findings of the studied group. Regarding the weight category, normal weight was higher, with 142 (71%) neonates followed by underweight with 58 (29%) neonates; it ranged from 2.88 to 3.90 kg with a mean value of  $3.4 \pm 0.33$  kg. Length ranged from 41.0 to 51.0 cm with a mean value of  $46.0 \pm 2.11$  cm. Head circumference ranged from 33.2 to 38.1 cm with a mean value of  $36.0 \pm 2.01$  cm.

Table 4 shows the distribution of the studied neonatal group regarding ultrasound findings. Of the 200 (100%) cases, those with normal findings were 177 (88.5%), and cases with positive findings were 23 (11.5%).

Table 5 shows the distribution of the positive cases regarding ultrasound abnormality findings. Three (13%) neonates had left hydronephrosis G II, with left pelviureteric junction obstruction. Two (8.7%) neonates had bilateral hydronephrosis with right pelviureteric junction obstruction. Two (8.7%) neonates had left multicystic dysplastic kidney and left mild nephropathy. Two (8.7%) neonates had an ectopic kidney. Two (8.7%) neonates had an enlarged kidney. Two (8.7%) neonates had right mild multicystic dysplastic kidney and left mild hydronephrosis. Two (8.7%) neonates had right mild hydronephrosis and dilated right ureter, and right vesicoureteric reflex.

One (4.3%) neonate had horseshoe kidney with mild bilateral hydronephrosis, and bilateral vesicoureteric reflux; one (4.3%) neonate had left renal stone, and left minimal hydronephrosis, one (4.3%) neonate had left multicystic dysplastic kidney, one (4.3%) neonate had bilateral G II hydronephrosis with bilateral vesicoureteric reflux likely on top of posterior urethral valve obstruction; one (4.3%) neonate had left renal cyst, one (4.3%) neonate had hydronephrosis G I, dilated external pelvis, and right pelviureteric junction obstruction; one (4.3%) neonate had polycystic kidney; and one neonate had nephropathy.

Table 6 shows the relation between positive cases of ultrasound abnormality and the sex of the newborn. Males with positive findings were 18 (78.3%) neonates, and females were five (21.7%) neonates, whereas males with negative findings were 100 (56.5%) and females were 77 (43.5%).

**Table 1: Distribution of the studied neonatal regarding their age**

Age (days)	n (%)
1-7	36 (18.0)
8-14	52 (26.0)
15-21	60 (30.0)
22-28	52 (26.0)
Total	200 (100.0)

**Table 2: Distribution of the studied neonatal regarding their sex**

Sex	n (%)
Male	118 (59.0)
Female	82 (41.0)
Total	200 (100.0)

**Table 3: Anthropometric findings of the studied group**

Anthropometric measurements	Range	Mean $\pm$ SD
Weight category		
Underweight	58	29.0
Normal weight	142	71.0
Weight (kg)	2.88-3.90	$3.4 \pm 0.33$
Length (category)		
Length (cm)	41.0-51.0	$46.0 \pm 2.11$
Head circumference (cm)	33.2-38.1	$36.0 \pm 2.01$

**Table 4: Distribution of the studied neonatal group regarding ultrasound findings**

US findings	n (%)
Normal	177 (88.5)
Positive findings	23 (11.5)
Total	200 (100.0)

US, ultrasound.

There was a statistically significant difference between positive cases of ultrasound abnormality and sex of the newborn ( $P < 0.05$ ) (Fig. 1).

Table 7 shows the relation between positive cases of ultrasound abnormality and the sex of the newborn. Nine (39.1%) of positive cases had age from 8 to 14 days, and seven (30.4%) of positive cases had age from 15 to 21 days, whereas 53 (29.9%) of the negative cases had age from 15 to 21 days and 51 of the negative cases had age from 22 to 28 days. There was a significant statistical relation between positive cases of ultrasound abnormality and the age of the newborn ( $P < 0.05$ ) (Fig. 2).

## DISCUSSION

This was a longitudinal study of 200 consecutive apparently normal neonates at Damietta University Hospital.

**Table 5: Distribution of the positive cases of ultrasound abnormality regarding the findings**

Positive US findings	n (%)	Age (days)	Sex
Left hydronephrosis G II, with left pelviureteric junction obstruction	3 (13.0)	10	Male
		6	Male
		12	Female
Bilateral hydronephrosis with right pelviureteric junction obstruction	2 (8.7)	4	Male
		6	Male
Left multicystic dysplastic kidney, left mild nephropathy	2 (8.7)	15	Male
		10	Female
Ectopic kidney	2 (8.7)	10	Males
Enlarged kidney	2 (8.7)	6	Males
Right mild multicystic dysplastic kidney and left mild hydronephrosis	2 (8.7)	12	Male
		10	Female
Right mild hydronephrosis and dilated right ureter, with right vesicoureteric reflex	2 (8.7)	20	Male
		15	Female
Horseshoe kidney with mild bilateral hydronephrosis and bilateral vesicoureteric reflux	1 (4.3)	15	Male
Left renal stone and left minimal hydronephrosis	1 (4.3)	9	Male
Left multicystic dysplastic kidney	1 (4.3)	7	Male
Bilateral G II hydronephrosis with bilateral vesicoureteric reflux likely on top of posterior urethral valve obstruction	1 (4.3)	6	Male
Left renal cyst	1 (4.3)	8	Male
Hydronephrosis G I, dilated external pelvis, and right pelviureteric junction obstruction	1 (4.3)	15	Female
Polycystic kidney	1 (4.3)	20	Male
Nephropathy	1 (4.3)	20	Male
US, ultrasound			

**Table 6: Relation between positive cases of ultrasound abnormality and sex of the newborn**

	Positive findings [n (%)]	Negative findings [n (%)]	Total
Male	18 (78.3)	100 (56.5)	118
Female	5 (21.7)	77 (43.5)	82
Total	23	177	
$\chi^2$		3.95	
P		0.045*	

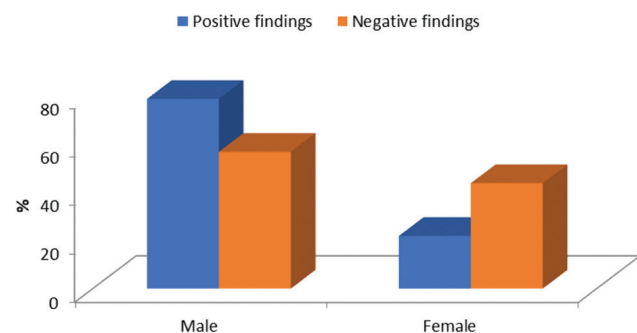
\*Significant statistical relation

**Table 7: Relation between positive cases of ultrasound abnormality and age of the newborn**

Age (days)	Positive findings [n (%)]	Negative findings [n (%)]	Total
1-7	6 (26.1)	30 (16.9)	36
8-14	9 (39.1)	43 (24.3)	52
15-21	7 (30.4)	53 (29.9)	60
22-28	1 (4.3)	51 (28.8)	52
Total	23	177	200
$\chi^2$		90.2	
P		0.001*	

\*Significant statistical relation

On prenatal ultrasound, the most frequently seen fetal abnormalities are those of the urinary system. Of these, hydronephrosis is the commonest, seen in ~50% of such cases, and it occurs commonly in males [5]. Fetal US evaluation of the urinary system is possible from the 15<sup>th</sup> week of gestation, but US at ~32 weeks of gestation is the best time for detecting

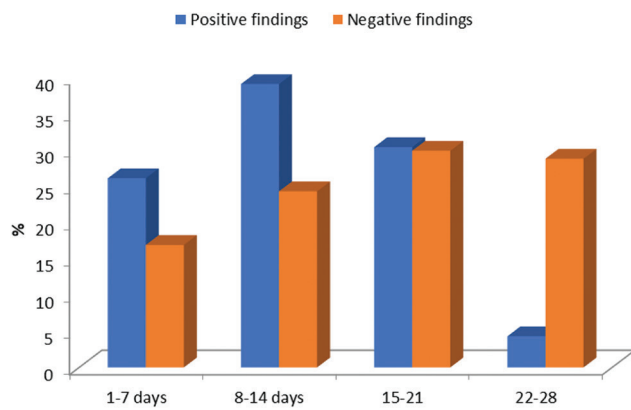
**Figure 1: Relation between positive cases of ultrasound abnormality and sex of the newborn.**

these abnormalities as an earlier scan in the same fetus may have normal results. For cases of hydronephrosis not diagnosed *in utero*, the role of postnatal abdominal ultrasound will be to determine the cases owing to obstruction that can lead to renal damage and therefore require surgical intervention or long-term follow-up of renal function [6].

In this study, the incidence of renal abnormality was found in 23 (11.5%) neonates; most abnormalities were found in males (78.3%). Moreover, most abnormalities were seen in a young group less than 20 days.

In this study, regarding the ultrasound abnormality findings, three (13%) neonates had left hydronephrosis G II, with left pelviureteric junction obstruction, two (8.7%) neonates had bilateral hydronephrosis with right pelviureteric junction obstruction, two (8.7%) neonates had left multicystic dysplastic kidney and left mild nephropathy, two (8.7%) neonates had an





**Figure 2:** Relation between positive cases of ultrasound abnormality and the age of the newborn.

ectopic kidney, two (8.7%) neonates had an enlarged kidney, two (8.7%) neonates had right mild multicystic dysplastic kidney and left mild hydronephrosis, and two (8.7%) neonates had right mild hydronephrosis and dilated right ureter, with right vesicoureteric reflux.

One (4.3%) neonate had horseshoe kidney with mild bilateral hydronephrosis, and bilateral vesicoureteric reflux, one (4.3%) neonate had left renal stone and left minimal hydronephrosis, one (4.3%) neonate had left multicystic dysplastic kidney, one (4.3%) neonate had bilateral G II hydronephrosis with bilateral vesicoureteric reflux likely on top of posterior urethral valve obstruction, one (4.3%) neonate had left renal cyst, one (4.3%) neonate had hydronephrosis G I, dilated external pelvis, and right pelviureteric junction obstruction, one (4.3%) neonate had polycystic kidney and one neonate had nephropathy.

The discrepancy between the studies may be accounted for by selection bias. The American study was carried out in private practice; only 25% of mothers offered an ultrasound examination for their babies agreed to participate. Perhaps these mothers chose to take part because their babies had occasionally been unwell even though the mothers did not report the illness. Brightly echogenic renal pyramids are known to be associated with disorders such as nephrocalcinosis and medullary cystic disease [7].

However, the US abnormalities persist in these disorders, whereas in our participants, they disappeared in less than 2 weeks. It is possible that this feature was owing to early neonatal dehydration, which causes transient deposition of protein in the renal collecting tubules – a self-limiting disorder with no apparent long-term sequelae. Because very few urological abnormalities were discovered during the first 3 months of our study, substantially fewer babies were subjected to secondary investigations in subsequent months.

As the informal assessment of pelvic dilatation was one of the factors on which a recommendation of secondary investigations was based, the detection of renal disease

may have been biased toward babies with greater dilatation. However, it is more likely that all children in the series with ureteric reflux or hydronephrosis still living locally have been found by the postal survey or the search of the medical physics departments' records. Such bias would amplify the apparent sensitivity of ultrasound screening [7].

However, more than half the children with hydronephrosis or ureteric reflux had only slight dilatation ( $\leq 5$  mm). Although only 11 cases were found, a larger study is not justified because ultrasound scanning is unlikely to be sufficiently sensitive for routine use. A Lancet editorial has suggested that ureteric reflux might be detectable by antenatal or early postnatal ultrasound scanning. Fetal ureteric reflux does occur and can be anticipated by antenatal scanning,[8-10] but most of the affected fetuses are male and have massive reflux, and many of their kidneys have evidence of damage at birth. They form a reflux population different from that we tried to muster, namely, children (mostly girls) with modest reflux but serious renal damage by the time the reflux is diagnosed [7].

Ramirez-Villalobos *et al.* [8] suggested that reflux could be anticipated by color Doppler imaging. However, they studied a small number of cases with a wide age range (26 days to 9 years). Although they found a significant difference in the distance of the ureteric orifice from the midline between children with and without reflux, there was substantial overlap between the groups, so the method is unlikely to be reliable in individual cases or very young infants. To determine whether the method has sufficient sensitivity and specificity to predict reflux, it will be necessary to study a large cohort of healthy infants.

Up to 60% of antenatally detected cases of hydronephrosis resolve spontaneously [9], and the threshold limit for spontaneous resolution of fetal or neonatal hydronephrosis has been put at Renal pelvis diameter (RPD) between 5 and 20 mm and Society for Fetal Urology (SFU) grade 1 to 2 by several authors [9].

This corroborates with the findings in this study, where persistent hydronephrosis was seen only in the cases with SFU grades 3 and 4 up to 4 months of age. It is, however, generally agreed that conservative management options should initially be considered for most patients. If postnatal USS is normal after 4–6 weeks of age, further US follow-up is unnecessary [7].

Ureteropelvic junction obstruction (UPJO) is the commonest cause of hydronephrosis owing to upper urinary tract obstruction in children and is seen in one in 1000–1500 births. There are intrinsic or extrinsic causes, and males are twice to thrice times more affected than females. It is bilateral in 10–40% of affected patients, with the left side being twice as affected as the right [10].

Classic US findings are dilated calyces and renal pelvis with the normal ureter, and this was seen in the two cases with grades 3 and 4 hydronephrosis who required long-term follow-up.

Approximately 25% of cases will have clinical and functional deterioration requiring surgical repair, but there is an increasing trend toward conservative management [11].

The decision for surgical intervention depends on the function of the affected kidney and the status of the other kidney at the initial assessment [12, 13]. As 13–42% of patients with UPJO have associated vesicoureteric reflux, micturating cysto-urethrogram (MCUG) is advised in all patients with this condition, as was done in the aforementioned cases [11].

The two cases with suspected UPJO had normal findings on MCUG with no evidence of vesico-ureteric reflux (VUR) or posterior urethral valves (PUV) noted. As diuretic renography is not available in our center, the patients are being followed up with serial ultrasound twice a year to monitor the degree of hydronephrosis and renal parenchymal thinning, and if these are progressive, surgical intervention will be considered. The ectopic kidney is one that lies outside the normal renal fossa (at the level of the first to third lumbar vertebrae) and is usually in the pelvis but may rarely be in the posterior thorax. The ectopic kidney may cross over to the contralateral side, where it may fuse with the second kidney (crossed renal ectopia) [11].

The incidence of the ectopic kidney is ~1 in 5000 from screening studies and 1 in 1000 from postmortem studies. Ectopic kidneys are associated with an increased incidence of other urological abnormalities, especially VUR, and are also prone to increased risk of trauma [11]. In a study by Lusch *et al.* [10], seven children with pelvic kidneys were symptomatic with recurrent urinary tract infection, abdominal pain, hypertension, and hydronephrosis. Regular US follow-up once or twice yearly was suggested for such symptomatic cases. The mother of the neonate with pelvic kidney in this study was counseled on these possible complications and recommended management.

### Summary

Neonatal abdominal ultrasound is usually performed to investigate neonatal symptoms and as a follow-up to evaluate fetal abnormalities, which were detected on prenatal ultrasound.

The role of the prenatal ultrasound has evolved in its specificity (93–99%) and sensitivity (14–85%) for the identification of fetal malformations over the past 5 decades and has partly contributed to the lowering of fetal mortality rates. More abnormalities are seen by the third trimester, and a single early scan may miss some fetal anomalies. This implies that some abnormalities may still be missed antenatally.

Moreover, early detection of any neonatal abnormalities by routine postnatal ultrasound for a newborn will contribute to early management and lowering morbidity. Examples of neonatal abnormalities that may be missed owing to incomplete antenatal follow-up include the following:

- (1) Absent kidney: prenatal abdominal ultrasound would show oligohydramnios and a persistently nondistended fetal urinary bladder.
- (2) Ectopic kidney: an ectopic kidney is a kidney that is out of place; an ectopic kidney is caused by a birth defect. In the case of an ectopic kidney, one of the kidneys does not move to the right place. It may remain in the pelvis. It may move upward but stop before it reaches its usual position. It may move higher than its normal position. A kidney may even cross over so that both kidneys are on the same side of the body. Sometimes it may even connect with the second kidney.
- (3) Malrotated kidney: it refers to an abnormal relationship between the renal pelvis and renal tissue. The condition may be isolated when it can be unilateral or bilateral, or be associated with other renal anomalies like an ectopic kidney.
- (4) Neonatal neuroblastoma: the early diagnosis is associative with higher survival.
- (5) Hydronephrosis: for cases of hydronephrosis not diagnosed *in utero*, the role of postnatal abdominal ultrasound will be to determine the cases due to obstruction which can lead to renal damage and therefore require surgical intervention or long-term follow-up of renal function; polycystic kidney incidental adrenal mass can be detected by ultrasound, but computed tomography is recommended.

There was a statistically significant difference between positive cases of ultrasound abnormality and the sex of the newborn. There was a statistically significant relation between positive cases of ultrasound abnormality and the age of the newborn.

### CONCLUSION

This study has been able to demonstrate an 11.5% incidence of various types of urinary anomalies in this sample.

### Recommendation

- (1) Even though the cost-benefit of early diagnosis and prompt treatment of significant renal abnormalities is high, recommending routine neonatal abdominal/renal US will most likely be hampered.
- (2) Public awareness on the possibility of detecting these cases early with resultant better prognosis should, however, be created such that parents who can afford such investigations can make informed decisions.
- (3) Routine postnatal US has been known to be very useful in early identification and prompt intervention of congenital renal abnormalities in the newborn.
- (4) More extensive and large-scale studied should be done for assessment of the role of routine abdominal ultrasound in newborns for the detection of renal abnormalities.

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Nil.

### Conflicts of interest

There are no conflicts of interest.

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