The role of ultrasonography for diagnosis the renal masses in children. Pictorial essay

Otilia Fufezan¹, Carmen Asavaie², Cristina Blag³, Gheorghe Popa³

¹ 3rd Pediatric Hospital, Cluj-Napoca, ² Radiology Department, Cluj-Napoca, Emergency County Hospital Cluj
² Emergency County Hospital Cluj, ³ 2nd Pediatric Hospital, Cluj-Napoca

Abstract
In children abdominal masses usually arises from the kidney and urinary tract. The reasons for patient’s presentation may be abdominal pain, palpable abdominal mass (usually discovered during the physical exam) and hematuria. Ultrasonography should be the first imaging investigation performed in children with an abdominal mass. It can be performed safely regardless of the clinical status of the patient, it is noninvasive and painless, requires no radiological contrast media and it is a relatively inexpensive. Ultrasonography is usually able to give an accurate localization of the lesion to a specific area or organ of the abdomen and provides good differentiation of solid from fluid or blood-filled masses. The purpose of this pictorial essay is to demonstrate the ultrasonographic features of the most frequently encountered reno-urinary masses in children.

Keywords: renal masses, hydronephrosis, differential diagnosis, children, ultrasonography

A. Solid Masses

1. Nephroblastoma or Wilms tumor
The most frequent solid abdominal masses in children are nephroblastomas (Wilms’ tumors) and neuroblastomas [1].

The nephroblastoma usually appears as a large renal mass that distorts the contour of the kidney and often has mass effect on surrounding structures. It has heterogeneous echogenicity due hemorrhage, fat, necrosis or calcification content [2] and associates vascular invasion therefore examination of the inferior vena cava, even right atrium is crucial to detect tumor extension in order to orientate surgical approach [3] (fig 1, fig 2).
The differential diagnosis includes firstly neuroblastoma and than other, not as frequent, solid renal tumors like congenital mesoblastic nephroma, rhabdomyosarcoma or renal cell carcinoma.

Fig 1. Nephroblastoma in a 1 year and 8 months girl. a) US longitudinal view shows a large, round, well-circumscribed, heterogeneous mass, with few hypoechoic areas inside at the inferior pole of the left kidney. There are no visible calcifications; b) transverse scan with color Doppler interrogation: there are no invasion signs within the left renal vein c) contrast enhanced CT scan coronal reconstruction (Hiperdia Imaging Diagnosis Center Cluj-Napoca collection) and d) axial sequence reveals the same features of the tumor: inhomogeneous, well-circumscribed left renal mass with heterogeneous enhancement, left renal vein does not show signs of thrombosis (Hiperdia Imaging Diagnosis Center Cluj-Napoca collection).
2. Bertin column hypertrophy

Homogenous renal masses should be differentiated in terms of their imaging features. Bertin column hypertrophy is a normal variant, but may sometimes mimic a tumoral renal mass. The specific cortical pattern permits to establish a correct diagnosis (fig 3). Fig 4 and 5 show also homogenous renal masses but in these cases represented by a malignant tumor and a posttraumatic renal hematoma.

Fig 2. Nephroblastoma in a 2 years old girl, after 1 month of chemotherapy a) the left upper pole of the kidney is occupied by a well-circumscribed, large, unhomogeneous mass with multiple hypoechoic areas, the lower pole of the kidney and the adrenal gland are visible; b) color Doppler interrogation in a longitudinal view shows no vessels in the tumor, renal vessels are displaced by the mass; c) transverse view reveals a permeable left renal vein; d) three-dimensional ultrasound examination allowed tumoral volume measurement (210 ml); e) postoperative aspect confirmed the ultrasonographic findings (Dr. C. Ordeanu personal collection, with permission).
Fig 3. Bertin column hypertrophy. a) gray-scale longitudinal view of the right kidney: ovoid, isoechoic to the renal cortex “mass” that is flanked by two pyramids with protrusion into the renal pelvis; b) color Doppler examination did not reveal a pathological vascular pattern.

Fig 4. US longitudinal view of the right kidney in a 5 months old boy: ovoid, well circumscribed, homogenous and hypoechoic mass that is disrupting the renal capsule. Histology revealed a nephroblastoma with anaplasia.

Fig 5. Longitudinal view of the left kidney shows an almost isoechoic, slightly inhomogeneous mid-renal mass with elevation of the renal capsule represented by a post-traumatic hematoma.

B. Fluid-Filled Masses

Hydronephrosis secondary to ureteropelvic junction obstruction is the most common cause of unilateral renal mass in childhood [4], but other causes of hydronephrosis are also frequently encountered like, the vesicoureteral reflux or the megaureter.

Often these patients are diagnosed ultrasonographically before birth. After birth the first imagining examination is also ultrasonography as it is able to evaluate the effect that these conditions have on the kidney (presence of dilatations, degree of hydronephrosis, parenchyma thickness, signs of infection). But further investigations, like voiding cystography or renal scintigraphy are necessary in order to establish the diagnosis [5].

1. Hydronephrosis due to ureteropelvic junction obstruction

In figure 6 it is presented the postnatal renal aspect in an antenatal detected bilateral hydronephrosis. The post-
Natal diagnosis in this 2 weeks old boy was: bilateral hydronephrosis, II<sup>nd</sup> degree on the right and IV<sup>th</sup> degree on the left. The ultrasonographic findings were suggestive for ureteropelvic junction obstruction. The postoperative outcome was favourable.

![Figure 6](image)

Fig 6. Hydronephrosis due to ureteropelvic junction obstruction. a) US longitudinal view of the right kidney shows mild dilatation of the collecting system. The calices are dilated, but their concave shape is kept; longitudinal (b) and transverse (c) views of the left kidney reveal an important dilatation of renal pelvis and calices, the renal parenchyma thickness is reduced, the calices are flattened, the anteroposterior pelvis diameter is 28 mm. The content of the collecting system appears to be transonic. There is no ureteral dilatation visible; d) longitudinal view of the left kidney 3 months after pyeloplasty shows improvement of the renal parenchyma and reduction of the collecting system dilatation.

2. Hydronephrosis secondary to vesicoureteral reflux

The correlation between the severity of hydronephrosis and the presence of vesicoureteral reflux is still unclear. In the present it is accepted that only high degree vesicoureteral reflux is relevant for urinary tract infections and renal scars [6]. Literature studies revealed that it is unlikely to find an abnormal voiding cystography in children with normal ultrasound examination [7]. Usually, the ultrasound exam is abnormal in children with significant vesicoureteral reflux. Figure 7 presents a right hydronephrosis in a 2-weeks old boy with urinary collecting system dilatation detected before birth. The cause of hydronephrosis turned out to be the presence of vesicoureteral reflux.
3. Congenital megoureter

Today most urologists apply a conservative management in vesicoureteral junction obstruction. Surgical treatment is reserved just for symptomatic patients or in case of renal function deterioration [8]. In figure 8 we present the case of a 3 weeks old boy with abdominal distention and antenatal suspicion of an abdominal giant cyst. The ultrasonographic postnatal aspect was characteristic for a congenital megoureter. Further imaging investigation were performed. The patient underwent surgery and the postoperative aspect was highly improved.

Fig 7. Hydronephrosis secondary to vesicoureteral reflux. a) The right kidney (longitudinal view) presents pelvic and caliceal dilatation and there is a small cyst in the medial cortex; b) the transvers scan reveals fluid-debris level in the renal pelvis; the aspect is characteristic for pyonephrosis; c) the voiding cystography (performed after infection healing) revealed the cause of hydronephrosis: severe right vesicoureteral reflux.
Fig 8. Congenital megaureter. a) coronal scan of the left flank showed a left kidney with a very thin parenchyma visible just in the middle area and lower pole, the adrenal gland is visible above the upper pole of the dilated urinary tract (s – spleen, ps – psoas muscle, cv – spine); b) longitudinal view in the left paramedian abdomen: from the kidney is emerging a very large transonic mass that is continued by a tubular, tortuous structure with a 3 cm diameter (giant ureter); c) transverse scan in the pelvis: the very enlarged ureter displaced urinary bladder on the right, urinary bladder has a normal wall thickness; d) voiding cystourethrography - anteroposterior projection: there are no signs of vesicoureteral reflux, the bladder is displaced to the right, but has otherwise a normal appearance; e) postoperative ultrasonographic aspect: the left kidney has no dilations and a good parenchyma thickness of 8 mm.
4. Reno-urinary anomalies and urinary tract infection

Some literature data proposes an early assessment of antenatal detected hydronephrosis to reduce the risk of urinary tract infection [9]. This part presents a few cases with urinary tract infection suggested by the ultrasonographic aspect.

Figure 9 presents a 3 years old girl with prolonged fever and altered general clinical condition. Ultrasound exam permitted the diagnosis of ureteral duplication, ectopic ureterocele and pyonephrosis. After antibiotic treatment and right nephrectomy the outcome was favourable.

A left antenatal detected hydronephrosis due to ureteropelvic junction obstruction in a five days old boy is showed in figure 10. The patient presented a good clinical status and ultrasonography was performed just for monitoring. The ultrasound findings allowed the detection of an urinary tract infection.

Figure 11 presents also a urinary tract infection detected by ultrasound exam in a 1 month old boy with antenatal detected hydronephrosis due to vesicoureteral reflux.

5. Multicystic dysplastic kidney

Ultrasonography allows a proper assessment and monitoring of the multicystic dysplastic kidney. In figure 12 shows the role of three-dimensional ultrasonography in cysts volume monitoring.
Fig 10. a) longitudinal view of left kidney and b) transverse view of the left kidney: the renal pelvis and calices show important dilatation with a pelvic diameter of 22 mm, the content of the collecting system is echogenic with floating spots inside, no dilatation of the left ureter visible.

Fig 11. a) oblique view ultrasound in the right upper quadrant: right kidney presents an echogenic parenchyma, moderate intermittent dilatation of the pelvis with thickening of the wall and mild caliceal dilatation; b) Longitudinal urinary bladder scan: right ureter is enlarged, urinary bladder and distal right ureter have an echogenic aspect suggestive for infection; c) transperineal scan revealed an ectopic implantation of the distal right ureter; proximal urethra is not enlarged; d) voiding cystourethrography (UCGM) performed after urine sterilization confirmed ectopic implantation of the right ureter, near to the bladder neck and revealed right vesicoureteral reflux.
C. Masses That May Mimic A Renal Mass

1. Neuroblastoma

Since neuroblastoma and nephroblastoma are the most frequent solid renal masses and because they arise in the same anatomic areas a differential diagnosis is always necessary. Table I shows some of the most important diagnosis criteria [10].

Figure 13 presents the abdominal ultrasound of a 3 years old boy with abdominal pain and palpable abdominal mass; the diagnosis was neuroblastoma. To show different features in neuroblastoma and nephroblastoma, figure 13f presents a large mass in the left renal upper pole; the mass is well circumscribed, unhomogeneous, echoic, with transonic areas inside, the aspect is suggestive for a nephroblastoma in a 4 years old girl.

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<th>Table I. Major criteria in differential diagnosis between nephroblastoma and neuroblastoma [10].</th>
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<td><strong>Nephroblastoma (Wilms’ tumor)</strong></td>
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<td>Calcifications are uncommon</td>
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<td>Extension into renal vein and inferior vena cava</td>
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<td>Patients usually 3-4 years old</td>
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<td>In most cases well circumscribed</td>
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<td>Displaces surrounding structure without insinuating between them</td>
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<td>“Claw” sign with kidney</td>
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Fig 13. Neuroblastoma in a 3 years old boy: a) US longitudinal view of the left kidney: there is large, poorly circumscribed, hypoechoic, inhomogeneous mass visible in the upper part of the left kidney, the renal capsule is disrupted and the kidney lost its shape; b) transverse section at the pancreas level reveals vessels integrated in the tumor; the aorta is elevated in relation to the spine (ao – aorta; vci – inferior vena cava); c) transverse Doppler examination of the celiac axis shows that vascular structures are encased in the tumor; d) and e) contrast enhanced computed tomography confirmed the ultrasonographic diagnosis: the aorta, the celiac axis, superior mesenteric artery and both renal arteries are encased in the tumor (Hiperdia Imaging Cluj-Napoca Center collection); f) longitudinal scan of the right kidney in a girl with nephroblastoma: the tumor is visible in the upper pole of the kidney, the lower pole is visualized and caliceal dilatations are present in it, the mass has no calcifications; adrenal structure is visible cranial to the tumor.
2. Adrenal hemorrhage

Adrenal hemorrhage is characterized by a hypoechoic or anechoic well limited mass above the upper pole of the kidney. This pathology resolves spontaneously by calcification. In figure 14 is presented a 2 weeks old boy with birth trauma and a large hypoechoic mass on the upper left kidney pole. Ultrasonicographic features permitted the diagnosis of adrenal hemorrhage. After 3 months calcification in the adrenal gland was found.

![Image](image1.png)

**Fig 14.** US longitudinal view of the left kidney: a) there is an oval, well circumscribed, inhomogeneous hypoechoic mass on the upper pole of the kidney, the mass has a thick wall, an echogenic septum inside, but no vascularization, the ultrasonographic aspect is suggestive for a left adrenal hemorrhage. b) after 2 months the mass has significantly reduced its size (2.3 cm) and is almost entirely hyperechoic; c) after 3 months: in this stage the adrenal mass is small (0.7 cm) and presents a hyperechoic calcified aspect.

### Conclusions

Modern ultrasonography is an extremely valuable technique in the detection and evaluation of renal masses. Awareness of the advantages and limitations of ultrasonography is essential both for an accurate diagnosis and avoiding other unnecessary imaging investigations.

First of all ultrasonography is able to distinguish solid from fluid masses with high accuracy. It offers information about localization, size, shape, echogenicity, effect of the lesion on the renal parenchyma, collecting system or the surrounding structures and appreciation of vascularization and lymph nodes.

When further investigations are necessary the differential diagnosis of these lesions usually benefits from the contribution of contrast enhanced CT, especially in the case of solid masses, and of voiding cystography or renal scintigraphy for some of the fluid-filled masses.
Bibliography