RENAL ABNORMALITIES EXCLUDING MASSES

By; Prof.Dr. Syed Amir Gilani

RENAL SONOGRAPHY

Ultrasound is a very valuable modality for evaluation of the kidneys. Although CT has superceded ultrasound in renal evaluation in many instances, it is still a very useful, quick, non-invasive, relatively inexpensive, ubiquitous technique

Lecture includes: congenital anomalies, hydronephrosis, papillary necrosis, nephrolithiasis, nephrocalcinosis, pseudokidney.

CONGENITAL RENAL ANOMALIES

Congenital renal anomalies include the following:

- renal agenesis / hypoplasia
- renal ectopia
- cross-fused renal ectopia
- horseshoe kidney
- duplex collecting system
- supernumerary kidney.

QUESTION:

Name several congenital renal anomalies identifiable by sonography.

ANSWER: Renal agenesis / hypoplasia, renal ectopia, cross-fused renal ectopia, horseshoe kidney, duplex collecting system, supernumerary kidney.

RENAL AGENESIS

In the adult population renal agenesis is a unilateral condition, since the bilateral condition is uniformly fatal in the neonatal period. The renal fossa is empty, as in the slide above, where only the psoas muscle is seen.The contralateral kidney undergoes compensatory hypertrophy.

Anomalies of the genitourinary tract occur in association with this condition. Most commonly this affects the uterus in the female and the seminal vesicles and vas deferens in the male. There is also increased incidence of dermoid cysts in the ovary.

In the fetus with bilateral renal agenesis, which is an autosomal recessive disorder, there is no urine production. This results in marked

oligohydramnios, which leads to pulmonary hypoplasia in the fetus. Even if a kidney could be immediately transplanted after birth, the neonate would die of the severely hypoplastic lungs.

There is no filling of a urinary bladder, however it may be very small, explained by a small amount of mucosal secretions.

QUESTION:

What other anomalies are most commonly associated with renal agenesis?

ANSWER: Other genitourinary anomalies, especially of the uterus, seminal vesicles and vas deferens. Also dermoid cysts of the ovaries.

RENAL AGENESIS

In a neonate born with bilateral renal agenesis, as in the fetus, the renal fossae are empty, however one must be careful, because the adrenals are prominent and descend into the renal fossae. They are often mistaken for small kidneys.

This slide shows an enlarged adrenal gland in the right renal fossa of a newborn that lived for 24 hours with bilateral renal agenesis. The adrenals were initially thought to represent small kidneys, both on the prenatal sonogram and after the baby was born. Once the baby was found to be anuric, all resuscitation procedures (because of the severe respiratory problems) were stopped.

QUESTION:

What is responsible for death in the newborn with bilateral renal agenesis?

ANSWER: Anuria and pulmonary hypoplasia

QUESTION: If a renal transplant could be performed in the newborn imme diately after birth, why would the neonate die anyways? ANSWER: Pulmon ary hypoplasia.

RENAL ECTOPIA

Renal ectopia means an abnormal position of the kidney.

As the result of growth and straightening of the curvature of the body, the normal kidney undergoes an “ascent” up the posterior abdominal wall during the sixth and seventh weeks of embryonic life. The ureter stretches to accommodate the kidneys, as they come to lie in the renal fossae. As they “ascend”, the kidneys undergo a 90 degree rotation medially, so that the renal hila face toward each other. Any kidney that fails to properly

ascend out of the pelvis does not rotate normally and remains essentially malrotated with its pelvocaliceal system facing anteriorly rather than medially.

The ascent of the kidneys can be arrested anywhere along their normal course and beyond.

QUESTION: How do kidneys become ectopic in their locations?

ANSWER: During embryologic life, they fail to ascend out of the pelvis into their normal positions in the renal fossae.

QUESTION: Why are ectopic kidneys also malrotated?
ANSWER: During the process of ascending out of the pelvis, kidneys also rotate 90 degrees. If the primary process is disrupted, then the kidneys do not rotate properly.

ECTOPIC PELVIC KIDNEY

When the kidney does not ascend out of the pelvis, it stays behind in the pelvis and is called a pelvic kidney. One or both kidneys may be affected. These kidneys are also malrotated and have anteriorly oriented pelvocaliceal systems, which are susceptible to obstruction.

Pelvic masses are not always recognized as easily as in the slide above. A central core of hyperechogenicity and a thick outer rim of hypoechogenicity should suggest the diagnosis.

HORSESHOE KIDNEY

Another congenital anomaly is the “horseshoe” or “U-shaped” kidney (transverse, arrows), which results from a midline fusion of the lower poles of the two kidneys. The connection of the lower poles may vary from a solid column of cortex to a thin fibrous strand, the latter of which would not be visible by ultrasound.

The kidneys are malrotated with the renal pelves projecting anteriorly. When scanning the renal fossa, a small, obliquely sectioned kidney may be seen (sagittal, arrows).

QUESTION:

What are the sonographic findings of a horseshoe kidney?

ANSWER:

The lower poles of the kidneys are fused by a solid column of isoechoic tissue, which lies over the great vessels in the retroperitoneum. The kidneys are malrotated with the pelvis protruding anteriorly.

HORSESHOE KIDNEY

Sometimes the horseshoe kidney is detected incidentally, when a thick hypoechoic band of tissue is found in the retroperitoneum crossing in front of the spine and great vessels. This appearance raises the differential diagnosis of retroperitoneal fibrosis and lymphadenopathy. Tracing the tissue laterally leads to the malrotated kidneys.

There is increased incidence of infection, calculi, Wilms tumor, transitional cell carcinoma and hypertension with horseshoe kidneys.

QUESTION:

Name some complications of a horseshoe kidney.

ANSWER:

Infection, calculi, Wilms tumor, transitional cell carcinoma and hypertension.

PARTIAL DUPLICATION

Duplications of the kidney vary from the mildest form, a bifid pelvis, to an extreme variety, complete duplication including the ureters. Duplications are quite common, occurring in approximately one out of five patients. They are mostly incomplete or partial types and most commonly affect the upper tracts.

Partial duplications of the kidney manifest as a solid column or band of tissue through the middle portion of the kidney bridging two sides of the cortex. The renal sinus echoes are split apart by this band of tissue, which is isoechoic with the renal cortex.

DUPLEX COLLECTING SYSTEMS

Partial duplications of the kidney manifest as a solid column or thick linear band of tissue (arrow) through the middle portion of the kidney bridging two sides of the cortex. The renal sinus echoes are split apart by this band of tissue, which is isoechoic with the renal cortex.

Patients are usually asymptomatic and the finding is not considered to be clinically significant.

DUPLEX COLLECTING SYSTEM

This is a more completely duplicated collecting system, because it extends into two ureters, which are obvious because they are dilated. The ureters may join at any point along their course or may remain as two separate ureters with two separate openings into the urinary bladder.

RENAL OBSTRUCTION

Renal obstruction or hydronephrosis occurs in 5% of renal failure patients, therefore patients with renal failure are examined first by ultrasound to determine if there is a surgically correctable cause of their obstruction.

If the obstruction is not relieved, irreversible renal damage ensues, because the increased vascular resistance accompanying the obstruction leads to permanent atrophy of the renal parenchyma.

Ultrasound is 95% sensitive and 98% accurate for the detection of hydronephrosis.

The fluid-filled dilated calyces coming together into the renal pelvis and separating the bright echoes in the sinus are readily seen in the middle of the kidney.

QUESTION: Unrelieved renal obstruction leads to:

A. Increased vascular resistance

B. Irreversible renal damage

C. Permanent renal atrophy

D. All of the above ANSWER: D

MILD HYDRONEPHROSIS

Degrees of hydronephrosis are usually described as mild, moderate or severe.

A mild degree of hydronephrosis causes slight separation of the central sinus echoes. The cortex is of normal thickness.

SEVERE HYDRONEPHROSIS

Severe hydronephrosis causes marked dilatation, rounding and blunting of the calyces and the renal pelvis. With severe hydronephrosis the cortex is thinned, which is an important feature of the severe category. (Thin means less than 1 cm thickness.) The center of this kidney is expanded by an anechoic structure, which has dilated, blunted, branches coming together into one larger area (“child’s gloved hand”), delineating a dilated intrarenal collecting system and hydronephrosis.

These are two different patients with severe hydronephrosis. Notice that the cortex is thin in both cases.

CALCIFICATIONS IN THE KIDNEY

Calcifications in the kidney may be due to calcifications in the collecting system, called nephrolithiasis, or in the parenchyma, called nephrocalcinosis.

Nephrocalcinosis may be of the medullary type, which has calcifications distributed within the medullary portion of the kidney, or the cortical type, which is in the cortex of the kidney. Medullary nephrocalcinosis is much more common than the cortical variety.

- RENAL OBSTRUCTION
- Occurs in 5% renal failure patients
- Irreversible renal damage
  - obstruction $\rightarrow \uparrow$ resistance $\rightarrow$ atrophy
- US: 98% accuracy for detection
- Pyonephrosis: medical emergency
  - urgent drainage
- PSEUDOKIDNEY SIGN
- Etiology
  - Mesenteric infiltration
  - Bowel wall thickening
- Causes
  - Lymphoma
  - Carcinoma
  - Inflammation e.g. colitis (Crohn's, UC, ischemic, infectious)

NEPHROLITHIASIS

Calculi (arrows) in the kidney present as hyperechoic foci that cast acoustic shadows. In the kidney calculi are not as easily seen as cholelithiasis in the gallbladder. There is usually not enough contrast around a renal calculus because there is not enough surrounding fluid to outline the stone or because the sinus echoes are so hyperechoic that they blend with the echogenicity of the calculus.

Another problem with renal calculi in the kidney is that normal structures in the sinus part of the kidney often produce focal bright echoes simulating small stones. In addition these structures may produce shadows, leading to the suspicion of stones.

Low gain, high frequency and placement of the stone in the focal zone are the best technical parameters for visualizing calculi and their shadows.

QUESTION: Sonographically why are renal calculi harder to see than gallbladder calculi?

ANSWER: Because there is less fluid around the stone, which blends with the bright sinus echoes.

STAGHORN CALCULI

When renal calculi become extensive they may fill the collecting system and literally make a cast of the intrarenal collecting system, which assumes the shape of a staghorn or coral, depending on your imagination. There is usually very little urine to outline the calculi.

SCATTERED TINY PUNCTATE CALCIFICATIONS

Multiple tiny punctate calcifications scattered throughout the entire renal parenchyma should suggest the possibility of HIV infection. These tiny hyperechoic foci are due to calcified granulomas and have been described in systemic infection with Pneumocystis carinii, Mycobacterium avium intracellulare and cytomegalovirus.

AIDS patients undergoing Pentamidine inhalation therapy for pulmonary Pneumocystis protect their lungs from the infection, but systemic levels are not high enough to protect against systemic spread of disease. Similar multiple tiny punctate calcifications are usually seen throughout other parenchymal organs, such as the liver, spleen and pancreas.

CORTICAL NEPHROCALCINOSIS

Calcifications in the kidney may also appear in the renal parenchyma, as opposed to the collecting system, and this is called nephrocalcinosis.

Approximately 5% of nephrocalcinosis is cortical and 95% is medullary in location.

The slide above shows a pediatric kidney with a thin hyperechoic cortex (arrow) due to cortical nephrocalcinosis. Most cases are bilateral and unfortunately fatal, due to very serious disorders, such as bilateral renal cortical necrosis.

QUESTION:

Which is more common: cortical or medullary nephrocalcinosis?

ANSWER:

Medullary nephrocalcinosis

MEDULLARY NEPHROCALCINOSIS

Medullary nephrocalcinosis affects the renal pyramids. This condition varies from a subtle distribution of the calcifications to a florid deposition of calcium throughout the pyramids.

Causes of medullary nephrocalcinosis

Hyperparathyroidism	RTA (distal)
Immobilization	Sarcoidosis
Drug-induced (thyazides)	Vitamin D toxicity
Milk-alkali syndrome	Metastases
Hyperoxaluria	Myeloma
Medullary sponge kidney	

Common thread: high calcium state

MEDULLARY NEPHROCALCINOSIS: EARLY STAGE

This slide shows echogenic borders surrounding the medullary pyramids (p), which is the earliest sonographic finding described in medullary nephrocalcinosis. The theory of the progression of calcium deposition in the medullary regions, termed the Anderson-Carr progression, begins with a high concentration of calcium in the fluid around the renal tubules. Calcium is normally removed by lymphatics, but as the amount exceeds the capacity of the lymphatics, calcium is deposited around the margins of the pyramids, which creates the hyperechoic borders. With time the entire pyramid develops calcium deposits and becomes hyperechoic.

MEDULLARY NEPHROCALCINOSIS: MIDDLE STAGE

In the middle phase faintly increased echogenicity is seen throughout the pyramids (arrows), which appear as echogenic triangularly shaped structures within the inner third of the three layers of the kidney (cortex, medulla, sinus). Usually there is no shadowing at this middle stage.

US is more sensitive than X-ray or CT in detecting these faint calcifications.

MEDULLARY NEPHROCALCINOSIS: LATE STAGE

In its late stage, medullary nephrocalcinosis causes diffusely hyperechoic pyramids with a fine to coarse echotexture. Shadowing is more likely to be present, often collective in nature, coming from the entire pyramid.

QUESTION:

List as many causes of medullary nephrocalcinosis as you are able.

What is the common denominator for most of these causes?

ANSWER: high calcium state

MEDULLARY SPONGE KIDNEY: EARLY

Medullary sponge kidney presents with increased echogenicity in the medullary regions of the kidney. This is a congenital abnormality due to tubular ectasia or dilated collecting tubules. Punctate calcifications precipitate within and around the tubules. Initially the calcifications are so tiny that only increased echogenicity is seen. At this stage ultrasound is more sensitive than Computed Tomography in detection of these fine calcifications. Later the calcifications become larger and can be resolved as small calculi (arrows). On intravenous urography small puddles of contrast radiate within pyramids, creating the so-called “paintbrush” appearance.

MEDULLARY SPONGE KIDNEY:ADVANCED

In its late stage clumps of calcium appear in the distribution of the pyramids and shadowing is present.

Sometimes this type of calcification is difficult to differentiate from staghorn calculi.

MEDULLARY SPONGE KIDNEY

A plain film radiograph of the abdomen in a patient with medullary sponge kidney shows fine punctate calcifications in the distribution of the medullary portions of the kidneys. CT scan would show more calcifications, but ultrasound is even more sensitive than CT in showing the microcalcifications.

PSEUDOKIDNEY SIGN

Thickening of the bowel wall or mesentery may produce a “pseudokidney” (arrows) or “atypical target” sign in the abdomen. As the bowel wall or the mesentery thicken to 5mm or more, the lumen of the bowel is compressed, but remains hyperechoic. The central echogenicity and the adjacent hypoechoic wall or tumor give the mass a renal appearance. Bowel is not easily recognized, because the typical layers are not apparent. Such changes are usually the result of mesenteric infiltration or bowel wall infiltration or edema. The causes include:

- Lymphoma
- Carcinoma
- Inflammation (e.g. colitis (Crohn’s, Ulcerative colitis, ischemic, infectious)

In the slide above the pseudokidney is due to a segment of small bowel with mesenteric infiltration in a terminally ill patient with widespread lymphoma.

QUESTION: What conditions are known to cause a pseudokidney appearance?
ANSWER: A pseudokidney appearance may be due to bowel wall changes (infiltration or edema) or mesenteric infiltration.

PSEUDOKIDNEY SIGN

The pseudokidney sign in this case was caused by lymphoma invading bowel and mesentery. Doppler studies in color and power reveal no evidence of normal renal vessels in the central echogenic regions, which were initially thought to be the sinus portion of the “kidney”. The central echogenic area is the location of the compressed bowel lumen.

PSEUDOKIDNEY SIGN

This patient had a pseudokidney sign in the right upper quadrant immediately under the liver. The appearance is that of bright central reflectors and a rim of hypoechoic solid tissue. The final diagnosis was ischemic colitis in the hepatic flexure of the colon. The right kidney was in normal position in the renal fossa, separate from the mass.