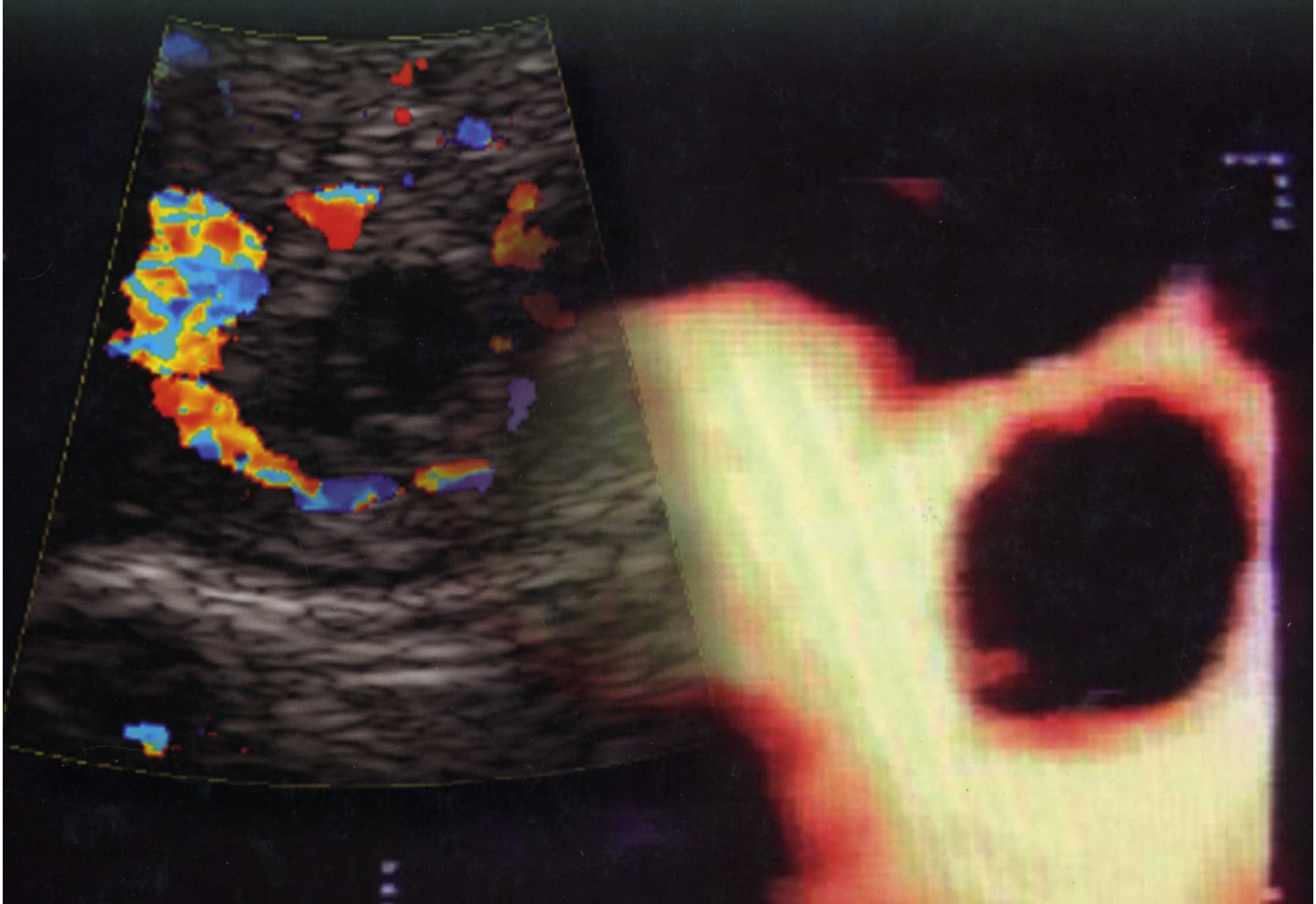
Practical Guide to EMERGENCY ULTRASOUND



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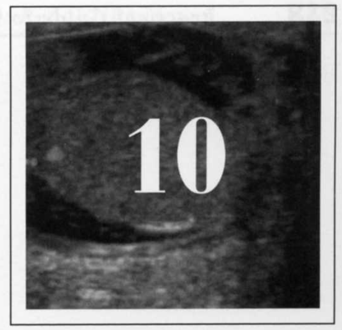

RENAL ULTRASOUND

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INTRODUCTION

Frequently viewed by emergency physicians as part of other ultrasound examinations, ultrasound of the kidneys is often overlooked as a valuable diagnostic tool. With computed tomography (CT) readily available in many institutions, renal ultrasound is often thought of as a second-line modality (1). However, a focused renal ultrasound can give valuable and rapid information at the bedside about renal obstruction. Consequently, once proficient at this exam, the emergency physician has a powerful tool in the evaluation of flank, abdominal, and pelvic pain.

CLINICAL APPLICATIONS

The primary clinical application of renal ultrasound in the emergency setting is for evaluation of acute flank or abdominal pain and/or hematuria (2). After appropriate training, emergency physicians can learn to identify hydronephrosis and intrarenal stones (3). The detection of hydronephrosis supports a clinical diagnosis of renal colic and possibly ureteral obstruction (4). The presence of bilateral hydronephrosis, in contrast, may be an important clue to a pelvic mass or bladder outlet obstruction such as occurs with benign prostatic hypertrophy, prostate cancer, and bladder cancer (5). The absence of hydronephrosis in the face of acute abdominal pain may, in some cases, lead the clinician to an alternative diagnosis.

In addition, renal ultrasound may aid the clinician in the initial assessment of acute renal failure to rapidly detect bilateral obstruction, which could lead to salvage of renal function (6). This is especially true in patients who may not be able to provide their own histories or make complaints. The clinical presentation of renal colic, pyelonephritis, biliary colic, and aortic aneurysm may overlap. Renal ultrasound examinations often flow into evaluation of other structures such as the gallbladder, liver, common bile duct, and aorta to detect other possible etiologies of acute pain. Once proficiency has been achieved, this simple bedside assessment for hydronephrosis can expedite the evaluation and treatment for many patients with complaints of flank and abdominal pain.

Image Acquisition

The ability to obtain quality renal images is one of the easier skills to master in emergency sonography (2). Both kidneys are relatively superficial; both are located adjacent to solid viscera (liver, spleen) that provide favorable acoustic windows. In addition, the kidneys are often used as reference structures for other abdominal ultrasound examinations, particularly the Focused Assessment with Sonography for Trauma (FAST) scan. It is important, nonetheless, to follow the same basic principles of all ultrasound examinations: scan slowly, scan methodically, and image in at least two planes in order to conceptually convert two-dimensional information into three-dimensional mental images.

Patients requiring emergency renal ultrasounds are often in considerable pain, especially those with renal colic. In order to obtain an adequate examination, it is essential that the patient's pain be controlled. It is necessary for patients to cooperate with instructions on how to position themselves and control their respiratory rate and pattern upon request by the sonologist.

The kidneys are best visualized in a fasted and hydrated patient (7). However, this is not always possible in the emergency setting. Bowel gas, ideally absent in the fasted patient, can present considerable interference during a renal ultrasound examination. Hydration status also affects the sonographic appearance of the kidney and bladder. Indeed, the state of hydration can mislead the examiner when attempting to determine the presence or absence of hydronephrosis. A well-hydrated patient may have a dilated renal pelvis that appears similar to mild hydronephrosis (8). A markedly dehydrated patient with obstruction may not demonstrate a dilated renal collecting system (9).

Most sonologists begin with the patient in a supine position similar to that used for general abdominal scans and scan from the anterior or midaxillary line (Figs.10.1 A–D, 10.2). This position provides the most intuitive location for anatomical structures when imaged with ultrasound. In order to build a three-dimensional mental image of the kidney from two-dimensional frames, all of the anterior, posterior, superior, inferior, medial, and lateral relationships of the kidney must be understood. Relationships between the liver and right kidney and between the spleen and left kidney are easy to conceptualize (Fig. 10.3).

It is important when using the supine view to have the patient lie as flat as possible. When the head or the trunk is elevated, the kidney tends to tuck under the rib margin, making renal imaging more difficult. In some circumstances, however, adequate visualization is not obtainable from the supine position. In these instances the patient can be moved to alternative positions, such as the right and left lateral decubitus or prone positions (Figs. 10.1B and D). In the decubitus position the kidney of interest is elevated, i.e., the left lateral decubitus position is used to visualize the right kidney. This allows for better use of both the liver and spleen as acoustic windows for kidney visualization. The prone position is rarely utilized but may be necessary occasionally. In this position, a pillow is placed under the abdomen to use the paraspinal muscles as an acoustic window. Often these positions are utilized in a stepwise fashion to obtain the best view of the kidney.

During the renal ultrasound examination, it may be necessary for patients to hold their breath or vary their respirations. When the patient takes a large breath, the expanding lungs push down the diaphragm and kidney toward the pelvis. This allows more of the kidney to be visualized from an anterior or midaxillary approach. Furthermore, rapid breathing can create so much motion that image quality degrades and interpretation is made more difficult. Therefore, it is often necessary for patients to hold their breath, usually at maximal inspiration, especially if motion-sensitive Doppler ultrasound is utilized during the examination.

A 3- to 5-MHz curvilinear array transducer commonly used for general abdominal scanning is appropriate for most renal scans as well (Fig. 10.4). This frequency provides a good compromise between adequate penetration and good resolution of renal structures. However, the sonologist should recognize small stones that may be encountered in the renal parenchyma might not be visualized at this resolution. Higher-frequency transducers, up to 7.5 MHz, may be used if the person is thin or if a small child is being scanned. If a curvilinear array transducer is used, it is important to recognize that only structures

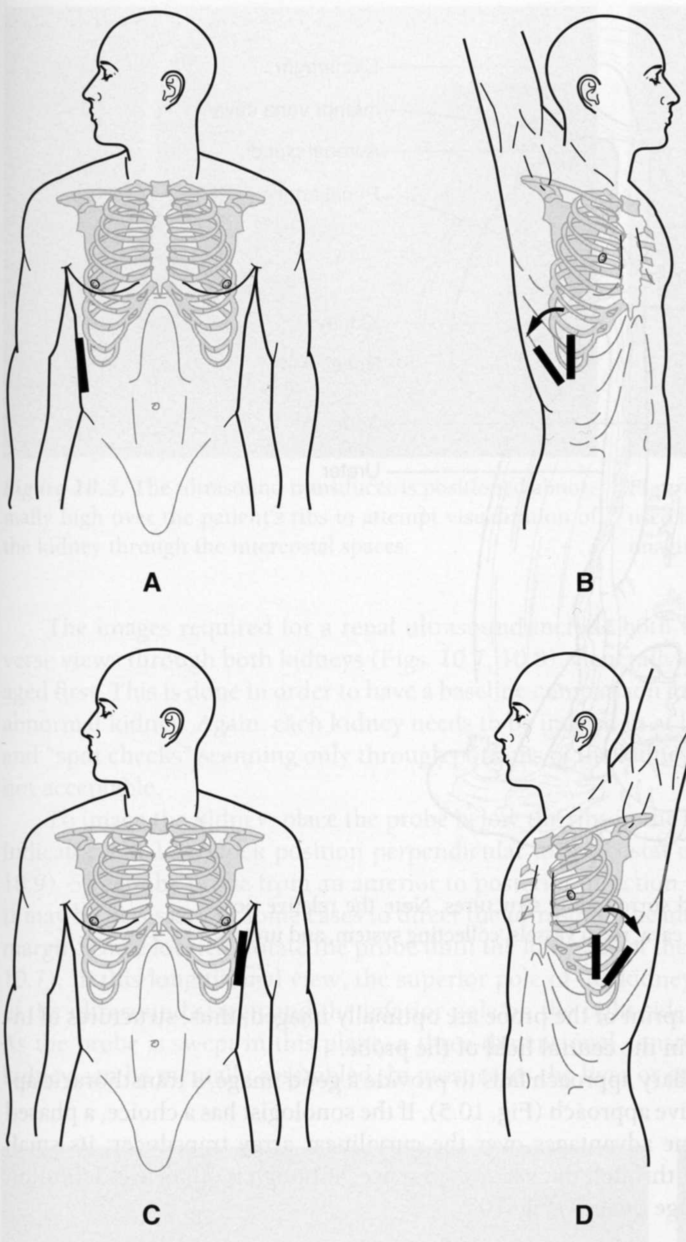

Figure 10.1. Guide to Image Acquisition. The kidneys can be imaged with the patient in a supine or lateral decubitus position. Place the transducer in the right flank and first image in the long axis of the kidney (A). Rotate the transducer 90° to view the short axis. Alternatively, the kidney may be viewed through an intercostal approach (B). The left kidney can be imaged through the spleen from a left flank (C) or intercostal (D) approach.

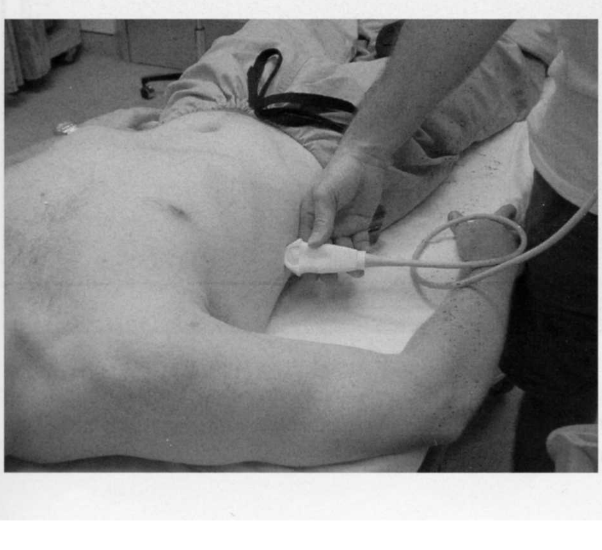

Figure 10.2. A patient is seen in the supine position. This is the typical starting point for an emergency ultrasound of the kidneys.

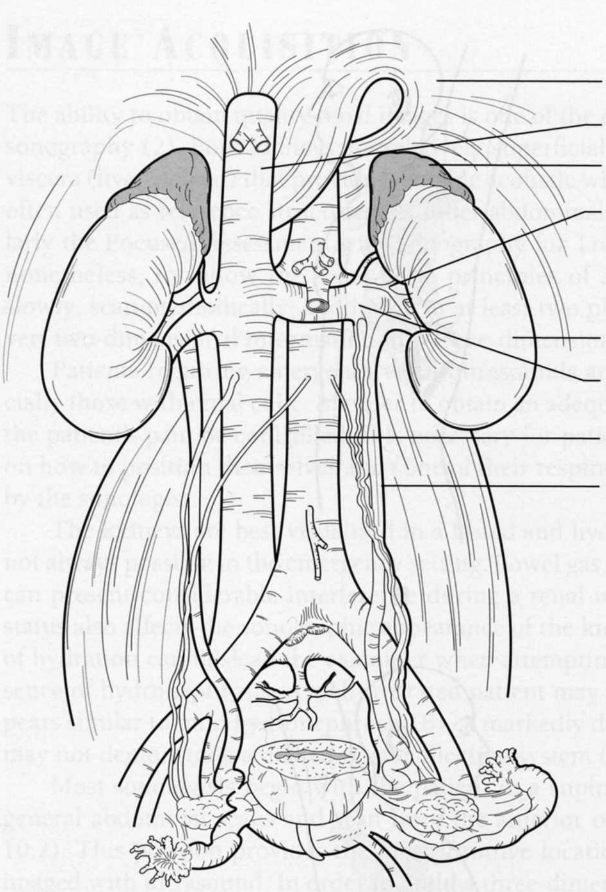

Figure 10.3. The kidneys and surrounding structures. Note the relative positions of the aorta, inferior vena cava, renal vessels, collecting system, and ureters.

directly in line with the footprint of the probe are optimally imaged; thus, structures of interest should be visualized in the central field of the probe.

When the standard axillary approach fails to provide a good image, a transthoracic approach provides an alternative approach (Fig. 10.5). If the sonologist has a choice, a phased array transducer offers some advantages over the curvilinear array transducer; its small footprint facilitates imaging through the narrow rib space, although it offers less definition and a somewhat poorer image quality (Fig. 10.6).

Figure 10.4. An image of a curved linear array transducer typically used for abdominal ultrasound.

Figure 10.5. The ultrasound transducer is positioned abnormally high over the patient's ribs to attempt visualization of the kidney through the intercostal spaces.

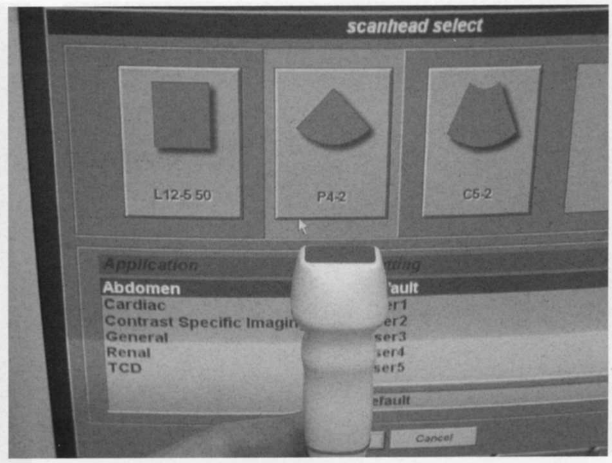

Figure 10.6. An image of a phased array transducer typically used for cardiac ultrasound but one that can be very useful for imaging the kidneys through tight rib spaces.

The images required for a renal ultrasound include both the longitudinal and transverse views through both kidneys (Figs. 10.7, 10.8). Generally the contralateral side is imaged first. This is done in order to have a baseline comparison for evaluating the potentially abnormal kidney. Again, each kidney needs to be imaged in at least two planes in entirety, and "spot checks" scanning only through portions of the kidney, such as the hilar area, are not acceptable.

To image the kidney, place the probe below the ribs in the axillary line with the probe indicator at a 12-o'clock position perpendicular to the costal margin (Figs. 10.1A and B, 10.9). Sweep the probe from an anterior to posterior direction until the kidney is located. It may be necessary in some cases to direct the ultrasound beam cranially, under the costal margin. Once located, rotate the probe until the long axis of the kidney is in full view (Fig. 10.7). In this longitudinal view, the superior pole of the kidney should be on the left side of the ultrasound screen and the inferior pole on the right side of the screen (Fig. 10.10). As the probe is swept in this plane, a three-dimensional construct of the long axis of the kidney can be mentally assembled. In most cases the liver or spleen is used as an acoustic

Figure 10.7. A longitudinal image of the right kidney is seen. No hydronephrosis or other pathology is noted. The superior pole of the kidney is on the left side of the image and inferior pole on the right side.

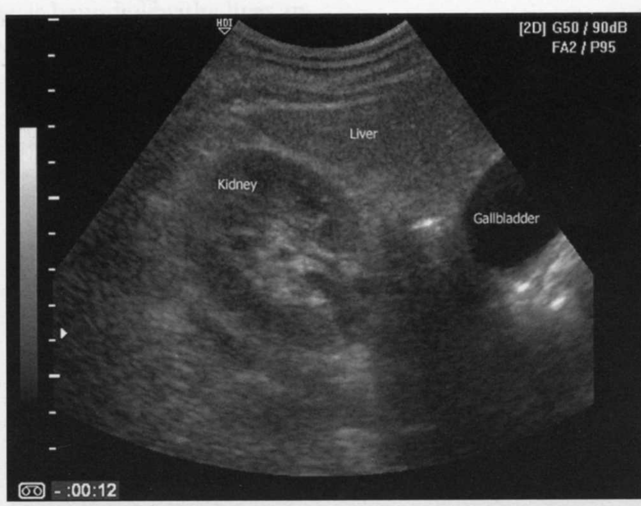

Figure 10.8. The normal right kidney is shown in short axis.

Figure 10.9. An ultrasound transducer is positioned on the patient's right side in preparation for a renal scan.

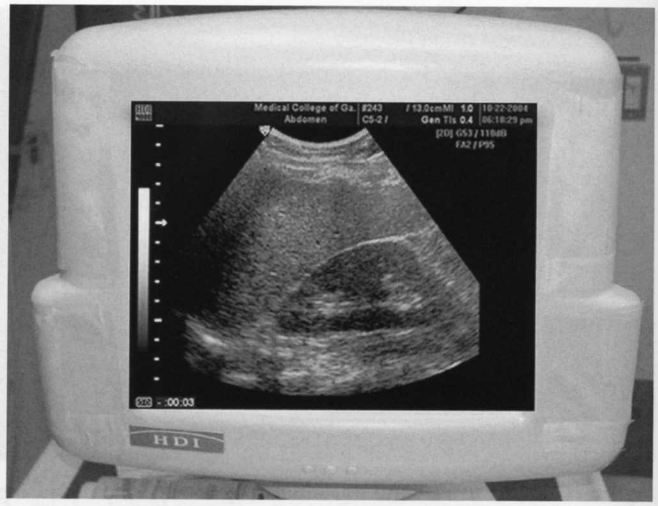

Figure 10.10. Image of the kidney on an ultrasound monitor.

window to provide an optimal image of the kidney. A noticeable difference will be appreciated in most cases when the liver or kidney is no longer under the transducer to provide a favorable window. When the transcostal approach is used, it is important to position the probe in a manner to minimize rib shadowing. It should be noted that the kidneys lie in an oblique orientation relative to the long axis of the body (Fig. 10.3). A true long axis view of the kidney may require that the transducer be rotated slightly away from the long axis of the body. For the right kidney, the probe indicator more commonly comes to rest at a 10-o'clock position to view the long axis; for the left kidney, the indicator may need to be oriented at 2 o'clock (Figs. 10.1B and D). Once the kidney is visualized, the sonologist should obtain the proper images based on internal guidelines and not artificial external landmarks. In other words, the image on the screen is matched to the sonologist's mental image of a standard renal view.

The transverse position view is obtained by rotating 90 degrees counterclockwise from the longitudinal view (Fig. 10.8). Transverse images of the kidney are made from the cranial to the caudal poles by angling the transducer along the length of the kidney. The hilum (located in the midportion of the kidney) should be imaged to assess the renal artery, vein and ureter (Fig. 10.11).

The right kidney is usually best imaged near the anterior to midaxillary line. This kidney is slightly more inferior in location than the left because the right kidney is displaced

Figure 10.11. Short axis image of the right kidney through the hilum. The artery (*A*), vein (*V*) and ureter (*U*) are seen exiting the kidney.

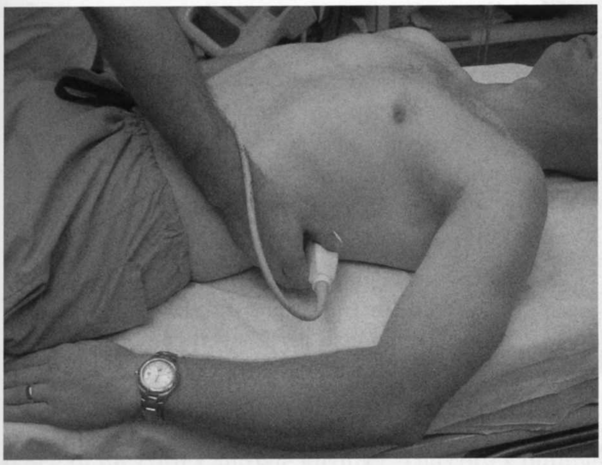

Figure 10.12. The transducer is positioned more posteriorly on the left side. This position may be required in many patients.

by the liver. The left kidney is typically best imaged between the midaxillary line and the posterior axillary line depending upon the size and location of the spleen (Fig. 10.12).

Once both kidneys are imaged in both the longitudinal and transverse views, comparison views are made. The dual function on the ultrasound allows display of both kidney images on one screen (Fig. 10.13). Similar views of each kidney are obtained. This allows for the comparison of the two kidneys. Labeling of each kidney is essential to prevent confusion.

Before concluding the renal scan the bladder should also be imaged. The transducer should be placed in the midline just above the pubis and the bladder imaged in two dimensions (Fig. 10.14). The bladder provides additional information that is often relevant to the renal scan. Occasionally pelvic pathology may be noted that will explain abnormalities detected in the kidneys, such as a dilated (obstructed) bladder.

Ultrasound Anatomy and Landmarks

The kidneys are paired retroperitoneal organs that lie lateral to the aorta and the inferior vena cava, and inferior to the diaphragm (Fig. 10.3). The kidneys are bounded by Gerota's fascia, a tough connective tissue that also surrounds the adrenal glands, renal hila, proximal collecting system, and the perinephric fat. The right kidney is bounded by the liver anteriorly, the liver and diaphragm superiorly, and the psoas and quadratus lumborum

Figure 10.13. Both kidneys are shown side by side to allow direct comparison.

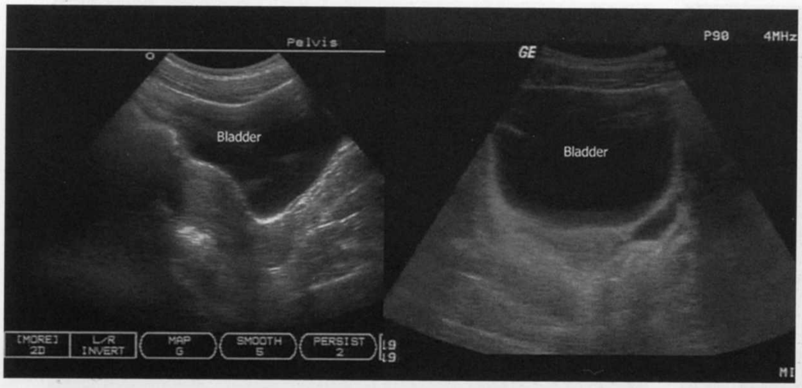

Figure 10.14. The bladder is seen in long and short axis. This should be part of every complete renal ultrasound examination.

muscles posteriorly. The left kidney is bounded by the spleen, large and small bowel, and stomach anteriorly; the diaphragm superiorly; and the psoas and quadratus lumborum muscles posteriorly. Both kidneys lie between the 12th thoracic and the 4th lumbar vertebrae. Usually, the right kidney is located more inferior than the left due to displacement by the liver, but position will vary with changes in posture and respiration.

The kidneys are connected to the body via the renal artery and vein and the ureter (Fig. 10.15). The renal arteries branch directly from the aorta laterally (10). Most of the population has a single renal artery; an accessory artery is present in 30% of the population (11). The renal vein drains directly into the inferior vena cava. The left renal vein crosses the midline of the body and can be seen in a transverse plane crossing between the aorta and the superior mesenteric artery as it crosses the midline toward the inferior vena cava (IVC). The right renal vein lies more proximate to the IVC and has a shorter course. The renal

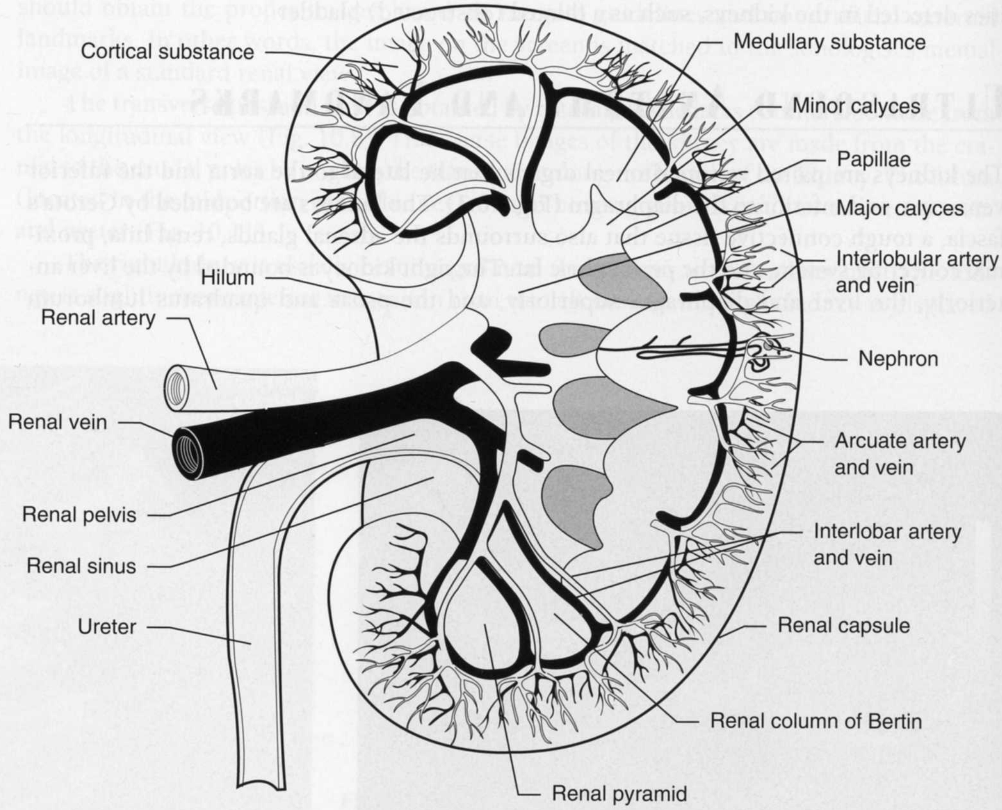

Figure 10.15. A cut section through a normal kidney shows the renal pelvis, the renal vessels, and the parenchyma. (Redrawn from Ma and Mateer, eds. *Emergency Ultrasound.* New York: McGraw-Hill Companies, 2003.)

pelvis drains into the ureter that travels parallel to the psoas muscles en route to the bladder (Fig. 10.3).

The kidneys are bean-shaped structures that average 9 to 13 cm in length, 4 to 6 cm in width, and 2.5 to 3.5 cm in thickness (Fig. 10.15) (12). Each kidney is surrounded by a fibrous capsule, the true capsule; an adipose capsule that contains perirenal fat; and the renal fascia known as Gerota's fascia. The kidney can be divided into two major parts: the parenchyma and the renal sinus.

The central portion of the kidney is referred to as the renal sinus. The sinus is comprised of the major and minor calyces, arteries, veins, lymphatics, and peripelvic fat (Fig. 10.15). The fibrofatty tissue within the renal sinus imparts a characteristic echogenicity. When the sinus is distended by excessive hydration or in the face of obstruction, the central renal sinus will be anechoic. The entrance to the sinus is referred to as the hilum. The minor calyces join to form the major calyces, which in turn join to form the renal pelvis.

The parenchyma surrounds the renal sinus on all sides except at the hilum and is composed of the cortex and the medulla. The cortex outlines the medulla, the functional unit of the kidney that is responsible for the formation of urine. The renal cortex tends to be slightly less echodense than the adjacent liver and spleen (Fig. 10.7). Abnormalities in this echotexture may reflect suboptimal gain control or intrinsic renal disease. The inner medulla consists of 8 to 18 renal pyramids that pass the formed urine to the minor calyces of the renal sinus. The pyramids of the medulla are called such because their structure resembles a pyramid with the base, the broader portion, directed toward the outer surface and the apex, or papillae, toward the sinus. The medulla is less echodense than the renal cortex. These subtle variations in echotexture within the kidney allow the sonologist to appreciate fine anatomical detail.

The renal arteries arise from the aorta. The renal arteries branch into the interlobar arteries and course between the medullary pyramids. The interlobar arteries divide into the arcuate arteries, which are found at the base of the medullary pyramid, and then into the interlobular arteries in the cortex.

Pathology

Hydronephrosis

When the ureter is unable to empty properly, the renal pelvis becomes distended with urine as long as urine production continues. The central renal sinus is composed of fibrofatty tissue that has a distinctly echogenic appearance. As fluid fills the collecting system, the usual echogenic (white) renal sinus becomes anechoic (black) surrounded by the thick, hyperechoic rim of the distended sinus (Fig. 10.16). The anechoic space takes the form and

Figure 10.16. Moderate hydronephrosis is shown in a long axis image of the left kidney.

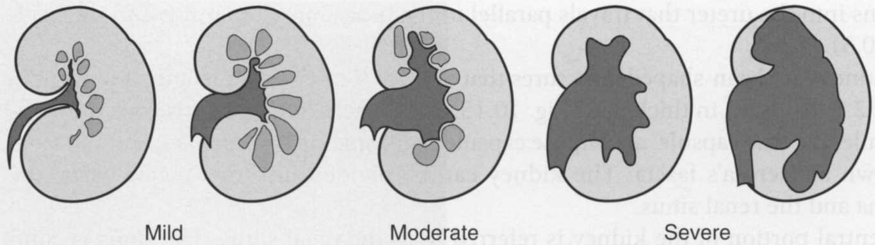

Figure 10.17. The grading of hydronephrosis. Mild hydronephrosis is noted by distension of the typically echogenic renal pelvis. Moderate hydronephrosis is seen to splay the calyces and distend the medullary pyramids. Marked hydronephrosis extends to the cortex. (Redrawn from Ma and Mateer, eds. *Emergency Ultrasound.* New York: McGraw-Hill, 2003.)

shape of the renal calyces and communicates with the dilated renal pelvis. The appearance of hydronephrosis is visually distinct and easily appreciated by ultrasound in most cases. Hydronephrosis is evidence of pathology within the collecting system, ureter, bladder, or even urethra. Hydronephrosis can be graded in several different ways. Perhaps the most common is mild, moderate, and severe (Fig. 10.17). Other grading systems such as 1, 2, and 3 are also used and are typically based on the appearance of the calyces (13). Mild hydronephrosis is characterized by prominence of the calyces and slight splaying of the renal pelvis (Fig. 10.18). Specifically, the renal pelvis does not appear as white as it does on the affected side and an area of darkness is seen. This grade of hydronephrosis may not be identifiable unless a comparison between the affected and unaffected sides is made (Fig. 10.19). On occasion a comparison to the contralateral side will reveal that no difference exists and

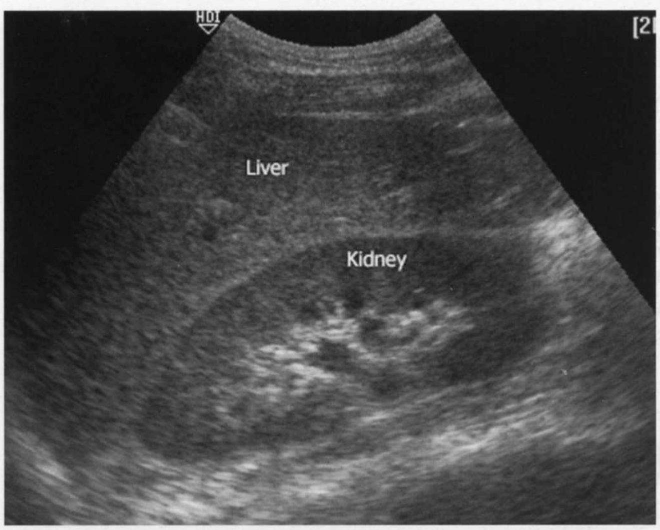

Figure 10.18. Mild hydronephrosis is seen in a long axis image of the right kidney.

Figure 10.19. A dual view helps compare the mild hydronephrosis of the left kidney (seen on the right) with the normal right kidney (seen on left).

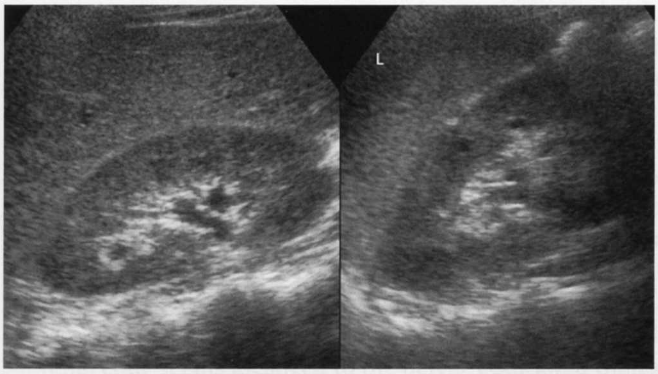

Figure 10.20. Dual view for comparison of mild hydronephrosis of the left kidney (image shown on right) that is identical to the image of the right kidney (shown on the left).

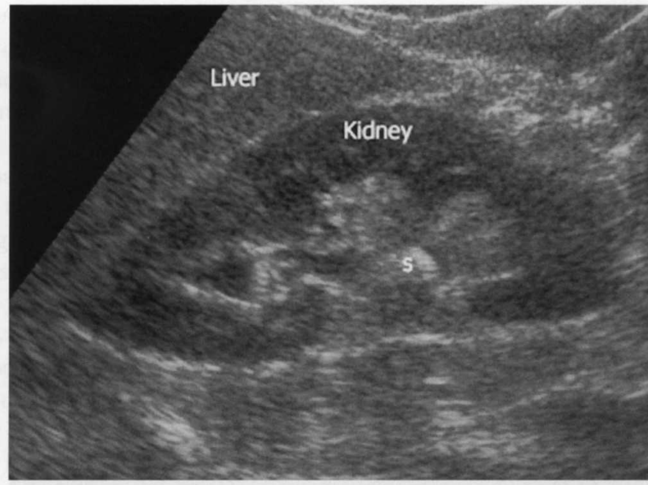

Figure 10.21. Moderate hydronephrosis is seen in the long axis of the right kidney. A large intrarenal stone (*S*) is also present.

the patient may simply be well hydrated (Fig. 10.20). Moderate hydronephrosis is typically obvious without comparison to the contralateral side, a comparison that should still be made for completeness (Fig. 10.21). The typically white renal pelvis is dilated with a large amount of dark space. The cortex is of normal echogenicity. It is of utility to use color Doppler to insure that what appears to be hydroureter is not actually ureter, renal vein, and artery laying side by side and giving the appearance of a dilated ureter (Fig. 10.22). Severe hydronephrosis shows significant dilation of the renal pelvis extending into the medullary pyramids toward the cortex (Fig. 10.23). The cortex is typically more echogenic and when the obstruction has been present for a long time the cortex can become very bright and may signify damage. Again, a comparison of the two sides is warranted.

Hydronephrosis itself is only a sign of pathology and does not identify a particular illness itself. Hydronephrosis occurs as a result of obstruction, either intrinsic or extrinsic to the genitourinary tract. The most common cause of hydronephrosis seen by the emergency physician is ureteral obstruction from nephrolithiasis. Up to 5% of the population will have renal stones identified at some point in their lifetime. Certainly, it seems that rarely a day goes by in many emergency medicine practices where renal colic is not seen or suspected.

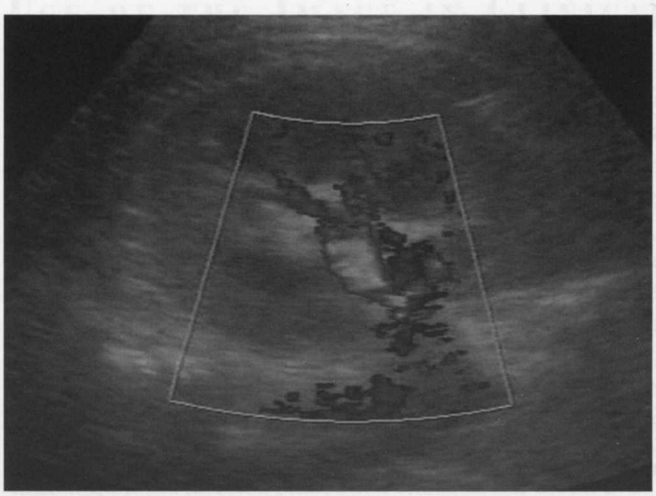

Figure 10.22. Color Doppler through the hilium of the kidney shows that an apparent enlarged ureter is actually vascular structures superimposed on the collecting system. (See color insert.)

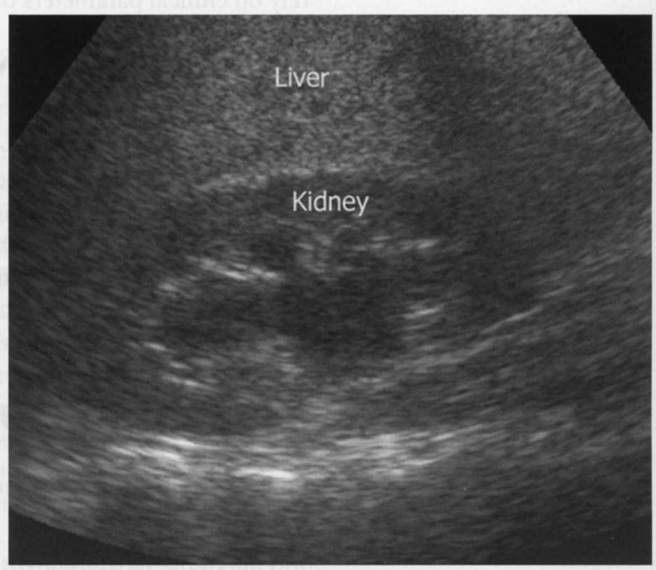

Figure 10.23. A long axis image of severe hydronephrosis.

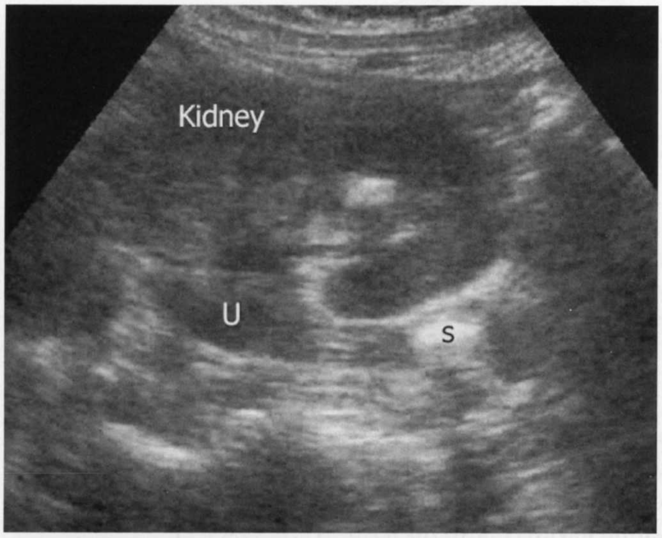

Figure 10.24. A large stone (*S*) is seen in the proximal ureter (*U*).

Hydronephrosis can also be caused by obstruction from other causes. Pelvic masses may cause unilateral or bilateral ureteral obstruction. These include ovarian, uterine, prostatic, and bladder masses, as well as retroperitoneal infiltrative processes. Some of these processes may be neoplastic, others benign.

Nephrolithiasis

Renal calculi may lodge anywhere within the genitourinary tract and can be visualized within the kidney itself, the ureter, and the bladder. Like calculi elsewhere in the body, they appear as echogenic structures with posterior shadowing. Stones that are large and/or proximal are easiest to visualize. Ureteral stones are unfortunately more difficult, often obscured by bowel gas. Occasionally, a stone may be visualized in a hydroureter when scanning conditions are optimal (Fig. 10.24). Whenever possible, it is helpful to locate the obstructing stone and describe its position and size. Stones larger than 7 mm are less likely to pass spontaneously and may require instrumentation. The ability to detect and describe these details can help determine the most appropriate management for individual patients. However, most emergency scans will not detect the stone and even experienced scanners will have to rely on clinical parameters or alternative imaging to make some management decisions.

Urinary Retention

Optimal renal scans should include the ureters and bladder. The bladder can be imaged from a suprapubic position. Assuming that the patient has not recently voided, the degree of bladder distention can give clues regarding the patient's volume status and renal function. When a patient presents with signs and symptoms suggesting urinary retention, the diagnosis can be confirmed by a scan at the suprapubic position. A distended urinary bladder is simple to detect by ultrasound. With limited experience, the sonologist may learn to recognize bladder wall thickening, evidence of chronic bladder outlet obstruction. In addition, scans of the bladder may help detect bladder calculi.

Artifacts and Pitfalls

Like any ultrasound examination, the renal exam comes with several pitfalls and challenges.

1. One of the most frequently overlooked limitations is the time course for hydronephrosis to develop. Patients that present and are seen rapidly after the onset of pain may not

have had enough time to develop hydronephrosis. This is especially true for patients who are not well-hydrated. Patients with significant pain can present with nausea and vomiting and thus have depleted intravascular volume and reduced urine production. In such patients, hydronephrosis is more likely to be seen after receiving intravenous fluid boluses (14).

2. Renal, ureteral, and bladder stones may be difficult to visualize. The ability to image an obstructing stone will depend upon the size of the stone, the location, and the quality of the ultrasound image (15). Small stones, nonobstructing stones, and stones obscured by bowel gas present a challenge. Ultrasound alone is not sufficient to image all stones; the inability to detect a stone does not rule out a stone. A few guidelines may help detect stones. A stone is typically lodged at the cutoff of a hydroureter. When the pain of renal colic seems localized to the pelvis, additional transabdominal views of the bladder and/or endovaginal views in women patients may be productive.
3. Not all stones that can be visualized are responsible for acute pain. Large proximal stones may be easy to visualize, but often serve as a source for smaller stones that themselves create the clinical picture of renal colic.
4. There are multiple causes of hydronephrosis, and clinical correlation is necessary to detect causes other than nephrolithiasis. Urinary catheter obstruction is a common cause of hydronephrosis in immobilized and chronically ill patients. In such cases the hydronephrosis is bilateral, unless one of the kidneys is nonfunctional. Bilateral hydronephrosis can also be seen in bladder tumors and prostate enlargement. Unilateral hydronephrosis can be caused by obstruction from any tumor or abscess constricting one of the ureters and typically arise from the bowel, ovary, or uterus.
5. The grade of hydronephrosis does not necessarily correlate well with either acuity or degree of obstruction (16). A recent but high-grade obstruction may have only mild hydronephrosis. Likewise, severe hydronephrosis may be due to past disease and not related to the acute illness. Patients with protracted hydronephrosis may develop permanent changes in the renal parenchyma. In the face of new symptoms and a complicated history, ultrasound may be difficult to interpret.
6. Of all pitfalls to avoid, the most significant one is fixating on the scan and neglecting sound clinical judgment. The ability to scan should not inhibit the emergency physician from keeping a broad differential and considering diagnoses outside the area scanned. Hydronephrosis has been described in cases of appendicitis and diverticulitis, when inflammatory masses obstruct the ureter. Flank pain can be the only symptom associated with an aortic disaster. The ability to image should enhance the bedside diagnostic skills, not distract or detract.

Use of the Image in Clinical Decision Making

How individuals incorporate bedside imaging of the kidneys into their clinical practice may vary significantly depending upon one's practice setting. The addition of fluid boluses to a patient's care who has a suspected renal stone is likely to result in hydronephrosis if a significant obstruction exists. Thus, if a large stone is present, signs of it should be found on ultrasound examination. Obviously mild or moderate hydronephrosis may be expected in most stones, and pain control will be the order of the visit. Follow-up can assure that pain resolves and the stone is passed. Marked hydronephrosis will be more likely to require earlier consultation and intervention. It is important to remember that, unlike intravenous pyelography (IVP) and CT scans, the ultrasound examination does not assess renal function to any degree. If bilateral severe hydronephrosis is identified then suspicion of decreased renal function is raised. Unilateral severe hydronephrosis may damage renal function on the affected side, but a check of the blood urea nitrogen (BUN) and creatinine may not indicate this if the other kidney is working properly.

Hydronephrosis itself does not pose a significant immediate danger to renal function (17). Studies differ on just how long is safe. Most cases of hydronephrosis secondary to renal stones will eventually resolve on their own as the stone traverses the ureter, bladder, and finally, the urethra (18). With relief of short-lived obstruction the hydronephrosis should decrease rapidly. If the hydronephrosis is severe and persists longer than two weeks, permanent renal damage may occur. This timeline is debated, although most physicians are surprised to find that hydronephrosis can be tolerated for so long. The management of obstructing renal stones and hydronephrosis will require consultation with and follow-up by a urologist to optimize outcome.

In all cases of flank pain, the clinician should always harbor some concern of the risk of aortic disease in the appropriate patient population. Whenever indicated, renal scans done to assess flank pain should progress to views of the aorta, particularly in the older patient.

Correlation with Other Imaging Modalities

Intravenous pyelography is the former gold standard for the evaluation of suspected renal stones and is still favored by some urologists (19). However, it has a number of disadvantages compared to newer imaging modalities (20). The use of intravenous contrast poses a risk of allergy and renal toxicity. In the abnormal scan, delayed images that are labor-intensive and time-consuming limit its usefulness clinically (21). IVP has largely been replaced by newer generations of spiral CT scanners that are now available in most hospitals. CT scans can give an indication of renal function (when contrast is used), and are excellent in visualizing renal stones. They provide additional information when the source of pain lies outside the genitourinary tract (22). Ultrasound occupies a unique role in the evaluation of flank pain. The use of bedside ultrasound by clinicians allows a rapid, noninvasive, and essentially risk-free method to rapidly detect hydronephrosis. Because the scan is quick and available at the bedside, serial exams can be performed if desired. Ultrasound is highly sensitive for the detection of hydronephrosis and is the test of choice for hydronephrosis (23). Compared to spiral CT, it is less sensitive for the detection and localization of renal stones (24). The combination of plain abdominal films combined with ultrasound may improve the ability to detect stones (25). The ability to detect other abdominal pathology is determined by the skill level and expertise of the sonologist. However, CT offers excellent detail and is generally cited as better than ultrasound at visualizing other conditions.

In general, ultrasound is unequivocally the best screening test for hydronephrosis available at the bedside at all hours. In patients with very typical renal colic and mild to moderate hydronephrosis, additional imaging may not be necessary. Emphasis for these patients can be focused on hydration and pain control. Patients with equivocal scans, those with marked hydronephrosis, those without hydronephrosis after adequate hydration, or patients in whom alternative diagnoses are under consideration may benefit from CT. Regardless, the use of bedside emergent ultrasound can expedite the evaluation and treatment for most patients.

Incidental Findings

A variety of masses may be detected incidentally during renal ultrasound examinations (26). Renal masses may present with acute flank pain from rapid expansion, mass effect with obstruction, bleeding, or abscess formation. The most common renal masses are simple cysts; occasionally more complex cysts and solid masses are seen (27). Renal masses can originate from the kidney or from adjacent organs. Differentiating an intrinsic renal mass from one that simply abuts the kidney may be difficult.

Simple cysts have a relatively smooth internal contour and few if any internal echoes (Fig.10.25). They typically occur on the cortical surface of the kidney and are peripheral in location, distinguishing them from an abnormal collecting system in the central kidney. However, perihilar cysts can occur and may be easily mistaken as hydronephrosis (Fig. 10.26). Simple renal cysts are common and rarely of any clinical significance unless they

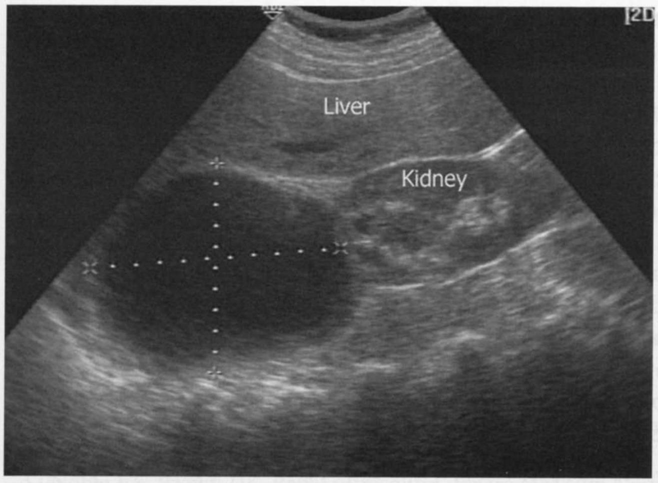

Figure 10.25. A large simple renal cyst is shown.

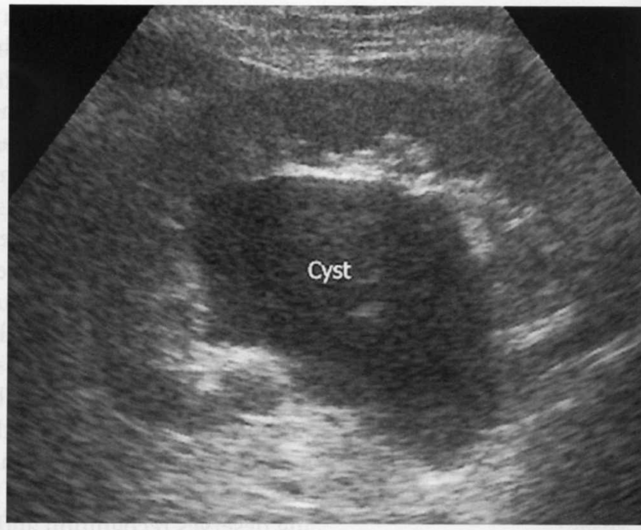

Figure 10.26. A perihilar cyst is shown. Such cysts can be confused for hydronephrosis or a hydroureter.

enlarge to a significant enough size to impair function of the kidney (28). If large enough they can distort the normal renal architecture. Occasionally renal cysts may become infected and present with flank pain and fever. In such cases, the patient may need emergent evaluation for drainage and antibiotics. Multiple simple cysts should raise the suspicion of polycystic renal disease, a diagnosis that will require long-term follow-up to detect and treat potential complications such as pain, hypertension, renal failure and associated liver disease (Fig. 10.27).

Complex cysts have a combination of echopoor and echogenic areas (Fig. 10.28). They differ from solid masses that have no cystic component. Complex cysts are more concerning than simple renal cysts; they may signify abscess, hemorrhage, or cancer. Occasionally solid masses may be identified within the kidney. Ultrasound criteria alone cannot distin-

Figure 10.27. An example of a polycystic kidney. The original architecture of kidney is completely obscured by multiple cysts of various sizes.

Figure 10.28. A complex renal cyst is shown with a mixture of fluid (F) and solid (S) components. The rest of the kidney is obscured by the abscess.

guish benign from neoplastic masses. Renal cell carcinoma has a variable appearance by ultrasound and can be hypoechoic, hyperechoic, or complex. All solid masses need definitive follow-up plans.

It is important to note that while some masses are obvious, some isoechoic masses may be difficult to detect by ultrasound. Emergency sonologists should not consider screening for renal masses a goal for emergency sonography. However, in the course of routine scanning of symptomatic patients, emergency sonologists will likely encounter incidental findings and should be prepared to obtain confirmatory imaging studies and appropriate, timely care. Nonetheless, the ability to detect and refer patients with renal masses is valuable and such findings should not be discounted or ignored because of indecision concerning the relevance of such abnormalities.

On some occasions, the sonologist may fail to visualize a kidney. The most likely cause is simply technique when bowel gas obscures the image in an obese or inadequately prepped patient. However, the sonologist should scan down to the pelvis, as occasionally a pelvic kidney may be found. This anatomical variant predisposes to stasis and infection and should have follow-up. Rarely, a patient may have renal agenesis. Again, such a finding deserves recognition and follow-up.

Clinical Case

A 26-year-old female presents to the emergency department with the chief complaint of right-sided abdominal pain. The patient states that the pain began two days ago primarily in her right flank and has moved over the last 24 hours to the right middle abdomen. The pain is constant and throbbing but waxes and wanes throughout the day. There are no modifying factors and she has never had this type of pain before. There is no history of trauma.

She has no past medical history, but is pregnant at 32 weeks gestation. This is her first pregnancy and she has had routine prenatal care and an uncomplicated prenatal course. She has had no past surgery. She takes prenatal vitamins and has no allergies.

Her review of systems is positive for several episodes of nausea and vomiting and mild dysuria. She denies fever, vaginal discharge or bleeding, and hematuria.

On exam, her temperature is 37.8 °C, her blood pressure is 110/70 mm Hg, pulse is 95 beats per minute, and respirations are 18 breaths per minute. She has a gravid uterus consistent with 30 weeks gestation. Her abdomen is nontender except for mild right flank and right costovertebral angle tenderness. She has fetal heart tones at 156 beats per minute. She has no vaginal discharge or bleeding; her cervical os is closed.

Significant laboratory results include 20 to 50 white blood cells (wbc) and 20 to 50 red blood cells (rbc) per high-power field, positive leukocyte esterase, small blood, bacteruria, and negative nitrate.

Her emergency ultrasound is shown in Figure 10.29.

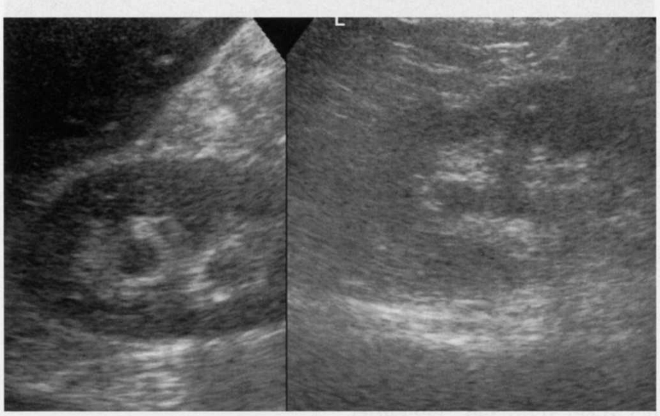

Figure 10.29. Bilateral hydronephrosis is shown.

The differential diagnosis in this patient can be quite varied. Though most consistent with a urinary tract infection or pyelonephritis, other diagnoses include renal colic due to an obstructing stone, biliary colic or cholecystitis, preterm labor, appendicitis, or placental abruption. Though a renal ultrasound may be useful in the evaluation of these other diagnoses, the presence of bilateral hydronephrosis may be confusing to the novice user of ultrasound. In this case, the bilateral hydronephrosis is likely due to ureteral compression due to the growing uterus and fetus.

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