Chapter 12: Renal and Bladder Ultrasound

KEY IMAGES

Long axis of kidney

Video 12-01: Normal kidney longitudinal image

This longitudinal view of the kidney demonstrates the white perinephric fat surrounding the darker cortex of the kidney. In the center is the hyperechoic renal pelvis, which is brighter due to the fat. The operator is fanning through the kidney to give a full view. Also visible are rib shadows, spleen, and some bowel gas. The operator is carefully adjusting the angle of the transducer to maximize the window between the ribs.

Play Video

Short axis of kidney

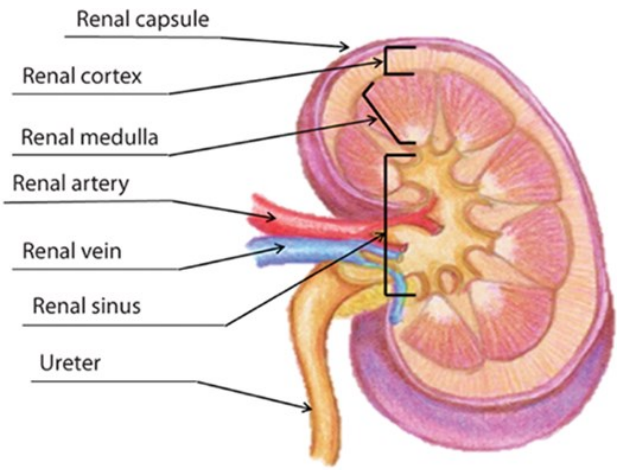
Video 12-02: Normal kidney transverse image

The operator has now rotated 90 degrees to demonstrate the kidney in the short axis. The operator then fans superior to inferior to evaluate the kidney from top to bottom. In this normal kidney the vasculature can be seen entering the renal pelvis as well as the spleen, aorta, rib shadows, and bowel gas. The operator is carefully adjusting the angle of the transducer to maximize the window between the ribs.

Play Video

Normal kidney anatomy

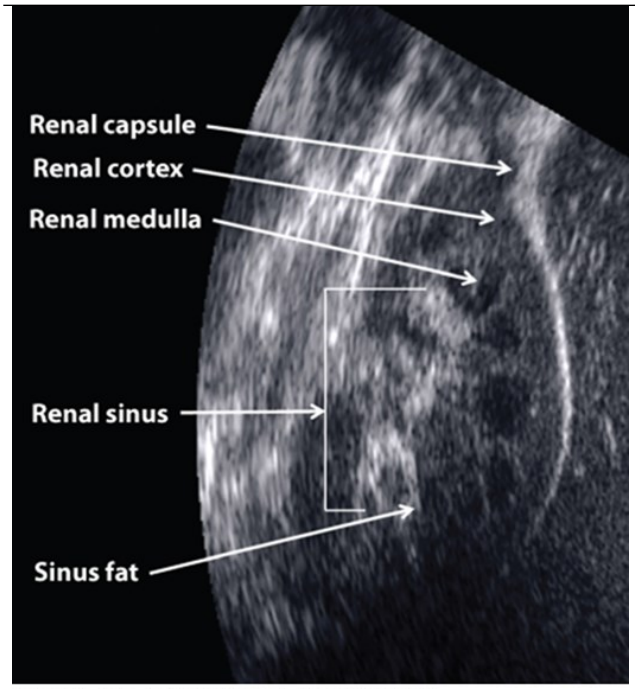
Figure 12-1



Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco: *Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound*, 1st edition.

Normal kidney image with labels

Figure 12-2

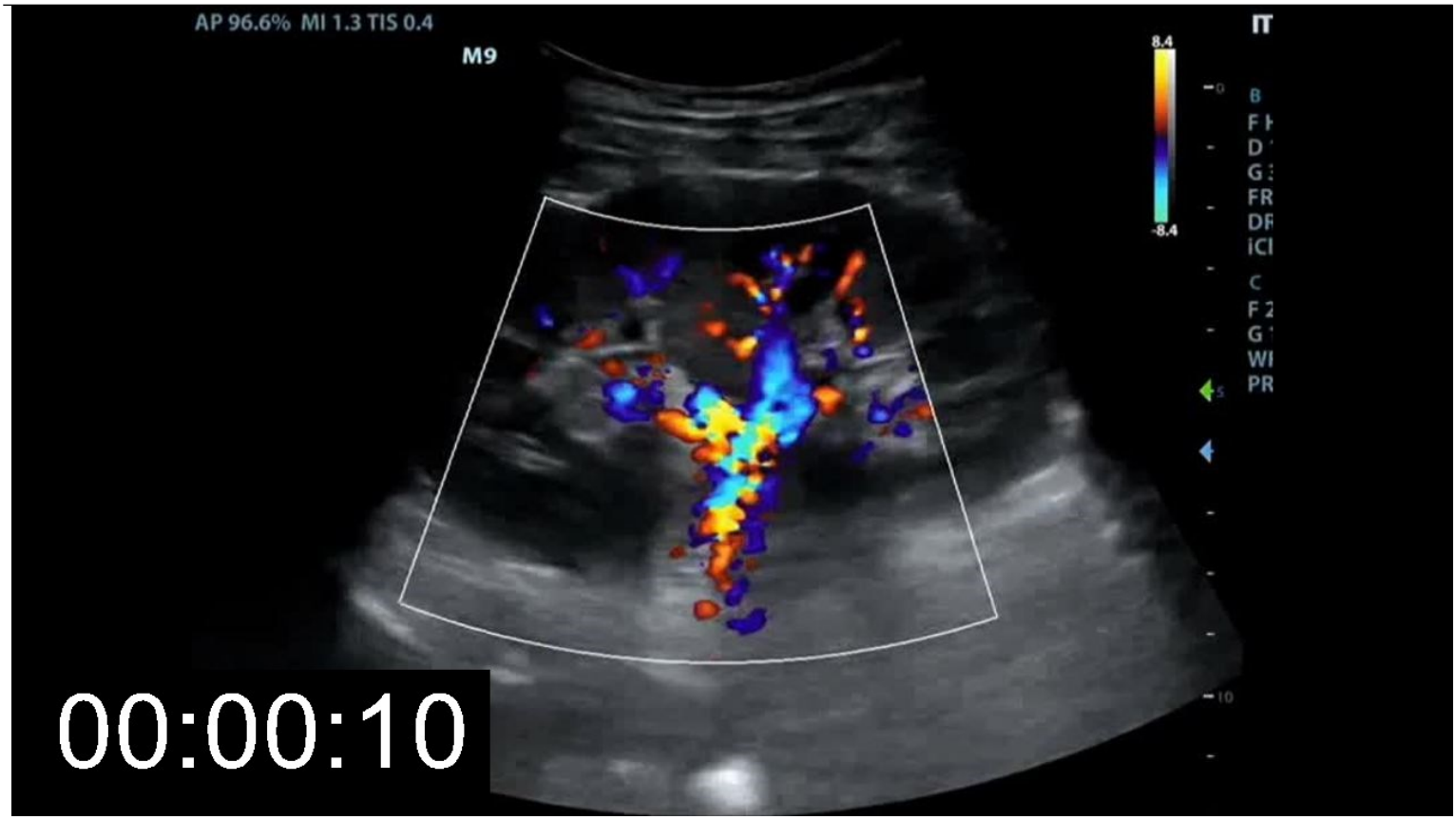


Source: C. M. Baston, C. Moore, E. A. Krebs, A. J. Dean, N. Panebianco:
Pocket Guide to POCUS: Point-of-Care Tips for Point-of-Care Ultrasound, 1st edition.

Color Doppler of normal kidney

Video 12-03: Normal kidney with color Doppler

Color Doppler is a more advanced ultrasound technique. This video demonstrates that the color has been set to detect low flow states. With this setting engaged, the blood flow in the renal arteries and veins are enhanced with color. The areas that remain anechoic are the urinary collection system. This technique can help distinguish vasculature from dilated collecting systems. It is important to remember that red and blue indicate directionality and not the oxygenation status of the blood.



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Female bladder, longitudinal

Video 12-04: Full bladder in a female pelvis

In this longitudinal view of the female pelvis, the anechoic bladder can be seen with a diamond shape. The uterus is visible to the left and deep of the bladder. Edge artifact casts shadows to the bottom of the screen from the curved edges of the bladder. The operator is fanning from left to right to evaluate the whole bladder. No free fluid is seen in the pelvis.

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Foley balloon in deflated bladder

Video 12-05: Foley balloon in empty bladder

If a urinary catheter is appropriately placed the bladder should completely empty. This clip demonstrates that in a male pelvis. The Foley balloon can be seen as an anechoic circle on the right side of the screen. Bowel makes up the rest of the findings seen in the clip.

Play Video

Female bladder, transverse view

Video 12-06: Full bladder transverse view

In the transverse view the indicator is rotated to point to the patient's right. The full bladder now has a more square or trapezoidal appearance. The uterus can still be seen deep to the bladder. The operator fans from the bottom to the top of the dome of the bladder in this evaluation.

Play Video

ACQUISITION TIPS

Hand position for right kidney

Figure 12-3

Hand position for left kidney

Figure 12-4

Renal

- Start with the probe at the posterior axillary line.
- Holding the transducer parallel with the ribs usually gives good longitudinal views.
- Fan toward the patient's back, aiming the beam toward the spine.
- Use long or oblique views to get between ribs. Rotate 90 degrees for short-axis view.
- It may help to have the patient take and hold a deep breath to avoid rib shadows.
- Placing the patient in lateral decubitus may help. Fan through the entire kidney so that it appears and disappears symmetrically on the image, ensuring that you are on the correct axis.
- Use of more than one rib space may be necessary to see the entire kidney.
- Use the liver as a "window." Aim the beam through the liver into the kidney.
- Compare the two sides to evaluate for pathology.

Bladder

- Place the probe midline and just above the pubic symphysis.
- For the transverse plane, rotate so the indicator faces the patient's right and fan from base to apex, starting with the pubic bone and scanning through the dome of the bladder.
- For the longitudinal plane, rotate so the indicator is cranial and fan from right to left, iliac vessel to iliac vessel.
- To visualize jets, use color or power Doppler. Use a transverse plane about 2 cm posterior/cephalad to the level of the urethra. The ureterovesicular junction (UVJ) typically appears as a subtle papule in the bladder wall. Set the scale to low, increase the sensitivity without creating artifact, and scan for up to 2 minutes.
- Jet frequency is dependent on the patient's hydration status and renal function. Jets should be symmetrical in volume and intensity.
- The most common site of impaction of stones is at the UVJ. Optimize gain, and search for shadow artifact.
- IV fluids running wide open can help visualize jets.
- To calculate bladder volume, make sure to acquire both transverse and longitudinal measurements.

INTERPRETATION AND PITFALLS

- Point-of-care ultrasound of the renal system is focused on the identification of obstruction. The signs of obstruction are hydronephrosis, hydroureter, and bladder distention. This is not intended to assess for medical renal kidney disease.

Hydronephrosis

- It is important to differentiate vascular structures, pyramids, and cysts from hydronephrosis.
- Hydronephrosis interdigitates into the renal sinus fat. Pyramids are not surrounded by echogenic fat, and cysts lack the interdigitating structure.

- Hydronephrosis contours to the parenchyma while each cyst is a discrete sac.
- Color Doppler may help distinguish hydronephrosis from vasculature. Increase the color gain until the window is flooded with artifact, then decrease it until only the renal vessels show color. If anechoic areas remain without color, hydronephrosis is present.
- Severity of hydronephrosis:
  - Mild: major calyces only dilated (hypoechoic line with bumps)
  - Moderate: major and minor calyces dilated (bear claw appearance)
  - Severe: parenchymal effacement (displaces renal cortex)
- Assessing for hydronephrosis can be difficult in polycystic kidney disease.

Bladder

- Look for masses that can cause obstruction. In men, these can be in the prostate.
- Visual assessment of prostate size can potentially explain a cause of obstruction.
- Evaluate whether there is a catheter balloon present. If so, the bladder should collapse.
- Visible renal jets make ureteral obstruction less likely. Their absence is less helpful.
- Bladder volume can be calculated using the “calculate” package on most machines or by hand; use length × width × height × 0.52.

Stones

- Stones are echogenic and may or may not shadow, depending on their size.
- For smaller UVJ stones, power Doppler may reveal a “twinkle” artifact.
- If hydronephrosis is present, follow the ureter from the renal pelvis along the psoas muscle to see whether a stone can be visualized.

Pelvic Cysts

- Cysts are anechoic fluid-filled structures with posterior acoustic enhancement.
- Pelvic cysts can mimic hydronephrosis. Use techniques outlined above to differentiate the two.
- Color may help to differentiate between simple cysts and solid masses, but requires advance Doppler skills beyond the scope of this text.
- Polycystic kidneys are very large, with numerous cysts of varying size.

Abnormal Echotexture

- Kidneys should have an echotexture the same as or darker than the liver or spleen.
- Small, bright kidneys with thin cortex are consistent with chronic kidney disease.
- Chronic kidney disease can present with kidneys of normal size and echogenicity despite advanced disease.

EXAMPLES OF PATHOLOGY

Video 12-07: Mild hydronephrosis

The hyperechoic renal pelvis in this kidney has an anechoic center to it. This black area separating the white of the renal pelvis does not even reach the edge of the anechoic area and has not yet begun to enter the cortex. This allows this dilation to be referred to as mild hydronephrosis.

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Video 12-08: Moderate hydronephrosis

In this clip the anechoic separation of the hyperechoic renal pelvis has dilated out to the edge of the cortex, creating a pattern of a tree root or a claw. There is not yet, however, erosion of the cortex, so this is moderate hydronephrosis.

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Video 12-09: Severe hydronephrosis

This video demonstrates the end state of hydronephrosis. The liver can be seen on the left side of the screen. The kidney in longitudinal view is dominated by the anechoic dilated pelvis with only a thin rim of echoic fat remaining. The cortex is clearly eroded in this severe state.

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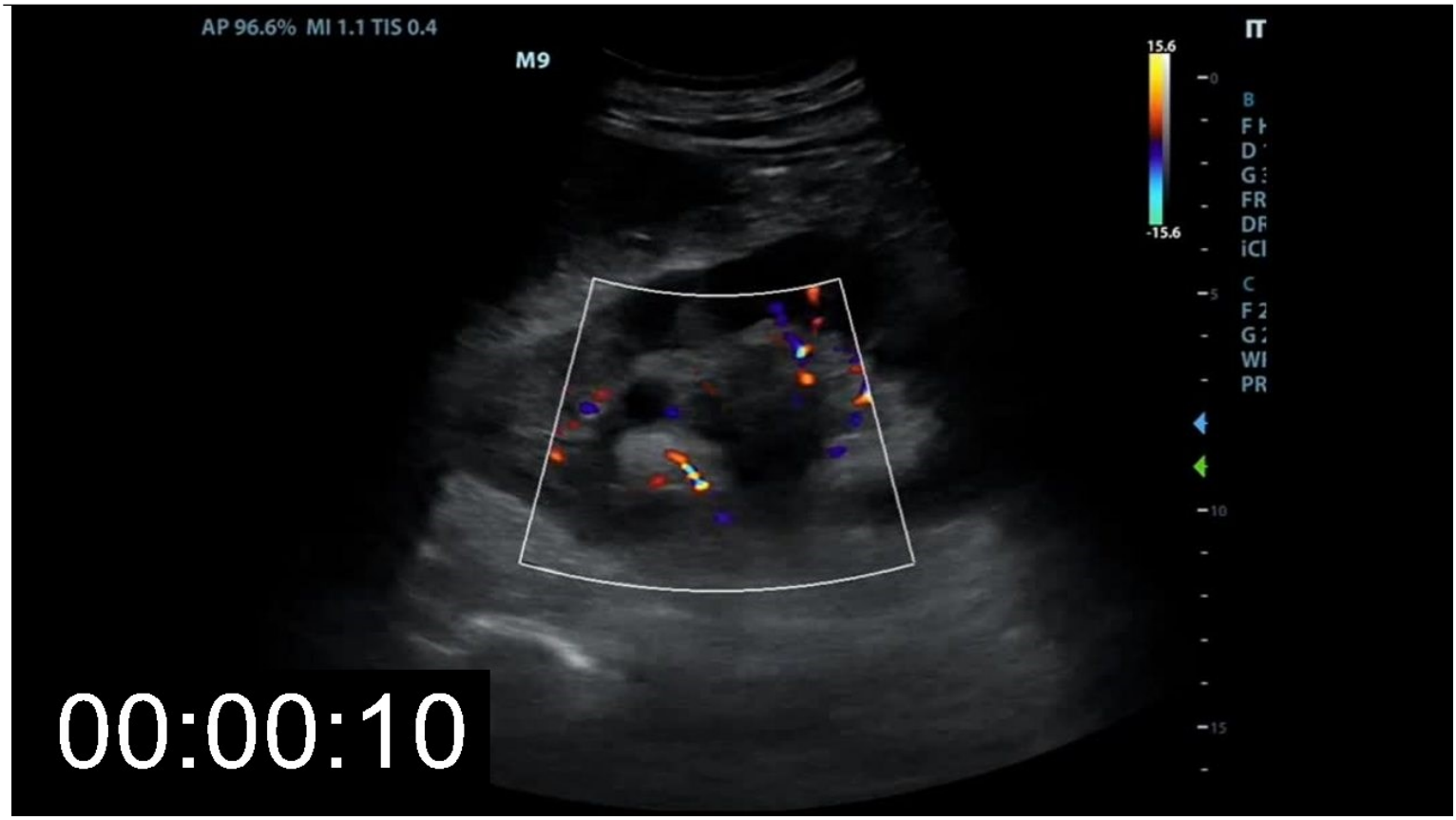
Video 12-10: Moderate hydronephrosis with color Doppler

When trying to determine if the anechoic region inside the pelvis is normal renal vasculature or hydronephrosis, color Doppler can sometimes be useful. In this case the color flow can be seen around the anechoic area, but not filling the anechoic area. That is consistent with moderate hydronephrosis.



Play Video

Video 12-11: Atrophic kidney

Assessing for medical renal disease is generally considered outside of the scope of point of care ultrasound, but this tiny right sided kidney is a clear marker of either severe longstanding disease, or in this case a congenitally atrophic right kidney.

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Video 12-12: Renal cyst

On first glance there might be concern for severe hydronephrosis in this left sided kidney. As the operator fans, however, it becomes clear that the anechoic area is not traversing the renal pelvis and collecting system. Instead, this rounded structure actually protrudes beyond the boundary of the renal cortex. This cyst is not reflective of an obstructive process. Differentiating simple cysts from complex ones like this is possible with ultrasound, but generally considered outside of the domain of the point of care sonologist.

Play Video

Video 12-13: Ureterovesicular junction stone

While slowly fanning through the bladder in this case a stone was noted in the uretero vesicular junction. This is a hyperechoic line with a dark shadow behind it seen in the lower right part of the screen. This should not be confused with the edge artifact seen on the left side of the screen. With color Doppler, stones like this can sometimes be seen to "twinkle" due to motion from the backed up ureter.

Play Video

Video 12-14: Intrarenal calculi

Fanning through this left kidney it was noted that there were several shadows that came from the kidney instead of from ribs more superficial to the kidney. In particular, there is a large stone on the right side of the screen that can be seen as a bright white structure with a dark shadow behind it. There are several other intraparenchymal stones, but no signs of hydronephrosis, which is not uncommon.

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