

Ultrasound

Renal Ultrasound

Ureterolithiasis: CT vs. US Risks and Benefits

- **CT Scan:** 85-100% sensitive, involves **radiation exposure**, expensive, **time consuming**, contraindicated in pregnancy, will identify **stone location and size**, has the ability to evaluate extra-urinary structures.
- **Ultrasound:** 80-94% sensitive, **no radiation**, inexpensive, **rapid**, **safe**, identifies **presence of obstruction** only (hydronephrosis, RARELY see the kidney stone), can evaluate for AAA, gallstones, and occasionally the appendix

Renal Anatomy and the Ultrasound

- **Renal Parenchyma:** Cortex, outermost layer, and renal pyramids shows up **gray**
- **Renal Sinus:** Central/Inner area including the fat and calyces, collecting system shows up **white** on ultrasound
 - *Specks of black in the middle of the white areas in the center of the kidney is renal vasculature, arteries and veins*
 - Reminder: **black (anechoic) on ultrasound is fluid**

Mechanics of the Renal Ultrasound

- Place the **probe** towards the **shoulders** (like in a FAST scan, but the probe moves slightly more lateral), at the **mid axillary to posterior axillary** lines
- On the right side you use the acoustic window of the liver. Can see upper pole of kidney, lower pole, gray on the outside area of the kidney, which includes the pyramids
 - Remember that the center is white with the collapsed collecting system and fat
- The left kidney can be harder to identify because the spleen is smaller and does not provide as good of an acoustic window as the liver
- Fan through both of the kidneys to look for hydronephrosis

Fun fact: With better ultrasound equipment you may be able to see small puddles of triangular-shaped darker areas within the peripheral layers of the kidney – these are the medullary pyramids!

Hydronephrosis

- While imaging the kidney, in the white center you will see a **black puddle** that **extends out into the poles**, and while fanning with the transducer to get a three-dimensional picture, the **collections merge** and become one and join the ureter, the fat is pushed towards the outside. These are dilated calyces and indicate obstruction.
- Hydronephrosis can be graded as **mild, moderate and severe**. The difference between these gradations is determined by clinical gestalt and experience.
 - Generally, the typical appearance of **moderate hydronephrosis** has been described as the collection system taking on the appearance of a **three leaf clover** / broccoli
 - In **severe hydronephrosis**, the **cortex and medulla are very thin** and pushed into the periphery

Fun Fact: Unlike kidney vasculature, hydronephrosis does NOT demonstrate flow on ultrasound. When it's difficult to determine the difference between the two, flow will distinguish mild hydronephrosis from vasculature in the kidney!

Flank pain Work-Up

1. Is there **hydronephrosis**?
2. Is the hydronephrosis **unilateral or bilateral**?
 - In males with bilateral hydronephrosis it is likely secondary to an enlarged prostate
 - In females with bilateral hydronephrosis it may be secondary to an enlarged pelvic mass
 - Do they only have ONE kidney? This will require more aggressive management
3. Is the **bladder distended**? If yes, have patient urinate and see if the patient has hydronephrosis before and after. This will change your management.
4. Is the **aorta** normal? **Adominal Aortic Aneurysm** can cause **left flank pain** and cause **hydronephrosis**

Hematuria Work-Up

1. Is the hematuria painful or painless? (e.g. kidney stone vs. cancer)
2. Is there hydronephrosis unilaterally or bilaterally? This may help narrow down the differential diagnosis.

Acute Renal Colic Work-Up

- **Situation A:** Focused renal ultrasound → no hydronephrosis → repeat US after hydration → no hydronephrosis → consider other cause for flank pain
- **Situation B:** Focused renal ultrasound → mild/moderate hydronephrosis → treat the pain → if improves discharge with follow up, and if does not improve consider CT scan and admission for intractable pain/vomiting/urology evaluation
- **Situation C:** Focused renal ultrasound → severe hydronephrosis → consider CT scan

Biliary Ultrasound

Emergency indications

- RUQ pain, biliary colic, hyperbilirubinemia (jaundiced patient), undifferentiated fever/shock

Anatomy

- Gallbladder (GB) parts: Fundus, Body, Neck (where stones commonly stuck)
- GB connected to cystic duct
- Cystic duct + Hepatic duct = Common bile duct (CBD)
- CBD + Pancreatic ducts = Ampulla of Vater (empties into Duodenum)
 - CBD stones: proximal = choledocholithiasis; distal = gallstone pancreatitis
- Portal Triad = CBD + Hepatic artery + Portal vein

Probe Positions

- Midclavicular line, between rib spaces 11/12, using liver as acoustic window (probe→head)
- Subcostal window, under window (probe→pt's right)
- Troubleshooting: lay patient on left side, have patient hold deep breaths (to push GB down)
 - **Exclamation Point Sign:** GB pointing toward the portal vein
 - MLF (main lobar fissure): thin white line that connects GB to portal vein
 - Hepatic artery and common bile duct run along same axis but anterior to portal vein

Cholelithiasis (stones in GB)

- Stones on US: bright white stones **with dense black shadow** behind it
- **Wall Echo Sign**: GB chock full of stones; can also be seen in porcelain GB
 - In the area you expect the GB, you see wall of GB and initial stone echo then all stone shadows blocking off the rest of your view of the GB

Choledocholithiasis (stones in proximal portal vein)

- US: **enlarged CBD (>6mm)**
- ****CBD** runs parallel to and on top of portal vein, can distinguish them with flow
 - ****Tip**: if you can see the CBD or it looks as big as the portal vein = enlarged. If you have to squint to see it = normal CBD
- CBD differs with age → add 1mm for every decade p 60 (but be cautious)

Acute Cholecystitis US findings

- **Gallstones**
 - Acalculous cholecystitis: rare in ED, usually end stage AIDS, ICU patients on TPN
 - May not always roll down to neck due to valves in GB
- **GB wall thickening > 3mm**
 - Measurements on **ANTERIOR wall**
 - Posterior wall cannot be measured because of acoustic enhancement
 - Also seen in fluid overloaded states (CHF, liver failure, renal failure) or contracted GB
- **Pericholecystic fluid (PCF)**: rim of dark fluid around GB (specific)
 - Can also be found in pancreatitis
- **Dilated CBD > 6 mm**
 - In choledocholithiasis or cholangitis
- **Sonographic Murphy's**: tenderness on palpation with US probe over GB fundus
- ****Surgery Consults** → evidence of cholelithiasis with/without gallstones (stone may have already passed), gallstones without evidence of cholelithiasis but refractory to treatment

Abdominal Aortic Ultrasound

Emergency Indications

- Abdominal pain, Flank pain, Undifferentiated shock, Syncope

Anatomy Review

- Aorta is cylindrical vessel that lies to the left of the IVC
- Anteriorly branching arteries off of the Aorta from superior to inferior: Celiac artery → Superior Mesenteric Artery (SMA) → Inferior Mesenteric Artery (IMA: so small likely won't see) → bifurcation into Iliac arteries
- To rule out Abdominal Aortic Aneurysm (AAA) you must visualize the aorta from the Celiac artery to the bifurcation of the Iliac arteries

Two Major Aneurysm Types

- Fusiform
 - Most common: generalized dilation of the aorta
 - Generally starts near the SMA and terminates at bifurcation of Iliac arteries
 - Can extend into the Iliac artery
- Saccular
 - Rare and difficult to diagnose
 - Saccular structure that balloons off the aorta, requires rigorous evaluation of entire aorta

Scanning the Aorta

- Short axis: Probe marker to patient's right
 - Push hard
 - Identify the spine (hyperechoic semicircle with shadowing behind it): two black dots (vessels) lie anterior to it, Aorta is on the left
 - Scan from epigastrium to the umbilicus
 - Aorta bifurcates into Iliac arteries at the level of the umbilicus
- Long axis: Probe marker toward patient's head
 - Scan from epigastrium to umbilicus
 - Aorta will be visualized as a long tubular structure
- **Troubleshooting:** If aorta is obscured by bowel gas, may need to slide probe to the right anterior/mid axillary line and use the liver as an acoustic window
- ****Normal Aorta is less than or equal to 2cm**
- **Aneurysm is considered to be Aorta diameter > 3cm**

****Caution: mural thrombus in AAA may be deceiving, revealing a lumen that appears normal; however the large surrounding clot is getting ready to burst!! Measure the diameter of Aortic wall (including thrombus) so you don't miss it!**

Pelvic Ultrasound in Pregnancy

Emergency indications

- First trimester abdominal pain or bleeding
- Third trimester abdominal pain or bleeding
- Trauma
- Undifferentiated shock

Pelvic Anatomy Review

- Full bladder optimizes transabdominal view
- Empty bladder optimizes transvaginal view
- Free Fluid (black/anechoic on ultrasound) collects in the cul-de-sac posterior to uterus and anterior to colon (aka Pouch of Douglas)

Transabdominal Pelvic Ultrasound in Pregnancy: Sagittal Plane

- Probe marker toward patient's head
- Full bladder optimizes view
- Looking for:
 - Signs of intrauterine pregnancy (IUP): gestational sac and yolk sac
 - Free fluid (black) behind the uterus and anterior to the colon (could indicate ectopic pregnancy)
 - If positive pregnancy test and no evidence of IUP on ultrasound, think **ectopic pregnancy!**

Transabdominal Pelvic Ultrasound in Pregnancy: Short axis/Transverse view

- Probe marker to patient's right
- Full bladder optimizes view
- Bladder will be located anterior to uterus
- Looking for:
 - IUP

- Free fluid posterior to uterus (Pouch of Douglas)

**** If an IUP is not visualized on transabdominal ultrasound, must proceed to transvaginal ultrasound to definitively rule out ectopic pregnancy**

Transvaginal Pelvic Ultrasound

- Probe marker towards the ceiling
- Empty bladder optimizes view
- Provides “wide angle view”
- Provides a view from superficial to deep of the cervix → uterus (with endometrial stripe) → fundus
- Sweep probe from side to side
- Looking for:
 - IUP
 - Free fluid posterior to the uterus (may indicate ectopic)

Transvaginal Pelvic Ultrasound: Short axis/Coronal view

- Probe marker to patient’s right
- Empty bladder optimizes view
- Uterus is “donut” shape
- Sweep probe up and down to image through the uterus
- Looking for:
 - IUP
 - Free fluid may indicate ectopic

Ectopic Pregnancy

- Most common location for ectopic is:
 - ****Fallopian tube- Ampulla (80%)**, Isthmus (10%), Infundibular (5%)
- Can also occur in cervix, ovary, peritoneum, interstitium of uterus (implants abnormally into wall of uterus)
- Job of ED physician is to locate IUP, if no IUP visualized, assume ectopic pregnancy until proven otherwise.
- **To confirm IUP we need to visualize two things:**
 - **Gestational sac** (Outer Sac)
 - **Yolk sac** (Inner Sac = “Cheerio Sign”)

When can I expect to see these structures on ultrasound??

Embryonic Structure	Transabdominal	Transvaginal
Gestational Sac	5.5-6 wks	4.5-5 wks
Yolk Sac	6-6.5 wks	5-5.5 wks

Discriminatory Zone

- Beta-HCG level at which IUP is expected to be visualized by ultrasound
- **If no IUP seen at that level, suspect ectopic!

	Beta-HCG
Transabdominal	3,000
Transvaginal	1,000

Sample protocol to rule out Ectopic Pregnancy in the pregnant patient with abdominal pain or bleeding:

- IUP visualized on ultrasound rules out ectopic pregnancy
- If no definitive IUP visualized:
 - If B-HCG < discriminatory zone and clinically asymptomatic:
 - Discharge home with close followup
 - Repeat US and B-HCG in 48 hours
 - If B-HCG > discriminatory zone
 - Comprehensive transvaginal utz
 - OB consult

Focused Assessment with Sonography in Trauma (FAST)

- Accuracy: CT > FAST > physical exam/diagnostic peritoneal lavage
- Indications: trauma, pregnancy (avoid CT), undifferentiated shock
- 4 traditional windows: right upper quadrant (RUQ; hepatorenal), left upper quadrant (LUQ; splenorenal), suprapubic, cardiac
 - One additional window in extended FAST: pleura

Right Upper Quadrant

- Probe marker to head, mid-axillary line, liver provides acoustic window
- Look for fluid:
 - Morison's pouch (potential space between right kidney and liver, visible as stripe of black if fluid present)
 - Inferior liver tip
 - Above/below diaphragm

Left Upper Quadrant

- Probe marker to head, posterior axillary line, knuckles to gurney
- Spleen more posterior and superior than liver
 - Not so important to look between spleen and kidney (vs. Morison's pouch)
- Look for fluid:
 - Above and below diaphragm
 - Around spleen
- Slight clockwise twist (up to 90°) of transducer can improve view of diaphragm and spleen when looking between ribs
- May need to fan probe to see everything

Suprapubic

- Just above pubic bone, 2 planes: marker superior for long axis, marker right for short axis
 - A full bladder provides the best acoustic window
- Look for fluid in rectovesical/rectovaginal pouch
 - Most sensitive view due to dependent position
- Turn down gain to improve sensitivity
- Prostate may initially resemble fluid on transverse (short axis) view, but appears dark gray (not black/anechoic) and easier to differentiate on sagittal (long axis)