Slide 6:

Regarding anatomy, the appendix can be found in the right lower quadrant originating from the cecum. It can often be found traversing medially over the common iliac artery and vein. In the left image, we see just this: the appendix originating from the cecum and gong over the iliac vessels.

The right image is an artist’s rendition representing a cross section of the lower abdomen. The appendix is may again be identified originating from the cecum and traversing over the iliac vessels.

Slide 7:

Furthermore, in addition to the underlying iliac vessels in the image on the left, it is clear that the psoas muscle often (but not always) lies directly posterior to the appendix as well.

The image on the right is a transverse CT scan at the level of the iliac crests. In the area highlighted the psoas muscle, iliac vessels, and appendix are seen in a common orientation.

Slide 8:

Unfortunately, it cannot be that easy. As illustrated in the leftmost image, the appendix can exist in the right lower quadrant in multiple different configurations. Indeed, 64% of the time the appendix is retrocecal – this is a particularly difficult location to view with ultrasound due to potential air in the cecum. Whereas, in contrast, it is found over the iliacs about 1/3 of the time.

The middle image represents a portion of a transverse CT scan at the level of the iliac crest. Near the center of the image, an inflamed appendix is seen coursing longitudinaly with the later aspect of the psoas muscle. It is clear from this image why movement of the psoas muscle can aggravate pain in appendicitis and indicate a retrocecal location.

Again, the rightmost image is another transverse CT scan of the lower abdomen. A positive arrow sign highlights the inflamed appendix located posterior to the cecum, medial to the iliac crest, and lateral to the psoas muscle.

Indeed, it is useful to consider these landmarks as boundaries for the location of the appendix. To restate, the appendix can nearly always be found bounded somewhere between the iliac crest laterally, the psoas muscle posteriorly, and the iliac vessels medially.

Slide 9

Now we’ll will move on and start talking about the actually scanning. For probe selection, the high frequency linear probe will provide excellent resolution but limited image depth. The curvilinear probe, alternatively, offers image depth, but a lower resolution image.

It is reasonable to start with the linear probe if you think it will have enough image depth, such as in a thin patient, or otherwise you can use the curvilinear. Note, that it is very simple (and reasonable!) to try one and switch to the other.

Slide 10

Scanning should be done in the supine position if it is tolerated. As we previously discussed, the appendix often lies directly anterior to the psoas muscle, so one positioning tip to move the appendix more anterior is to have the patient cross their right leg over their left. That is to say, apply a small amount of flexion at the hip.

Slide 11

There are a few ways to go about finding the appendix. One often successful method is to simply have the patient point to the location of most intense pain and just put the probe right there. In some patients, you can even have the place the actual probe where it hurts the most.

At this location you should slowly scan and apply graded compression to help move air away from that area of bowel. You should optimize your depth and gain. Starting off, you will want to have a high depth and the gain should, essentially, be adjusted for optimal contrast among the structures you are viewing.

As your scanning you should be looking for the appendix itself and landmarks that might help you found the appendix, including the iliac vessels, the psoas muscle, and the iliac crest. We will show lots of ultrasound examples and specific findings for these things shortly.

Slide 12

If your scan at the point of most intense pain was not fruitful, you should attempt to systematically search for the appendix in the right lower quadrant. You will basically, “mow the lawn,” looking thoroughly in sagittal and transverse views.

About 1/3 of the time, you simply won’t be able to find any part of the appendix.

About 1/3 of the time, you will find the appendix, but won’t see the all the relevant structures

And, about 1/3 of the time you’ll find everything!

I will note that not being able to find the appendix lowers the likelihood of appendicitis. Big, inflamed, fluid filled structures tend to be easier to find. I will talk more about integration of findings later in this presentation.

Slide 13

When you do find the appendix, it will be a small tubular structure less than 6 mm in diameter that is does not have peristalsis, is compressible, can be traced to the cecum.

I will start of by showing you some still images, and then we’ll look at some actual ultrasound clips.

In this image we can see the cecum on the left with it’s classic “dirty air” pattern followed by the origination of a non dilated appendix overlying the iliac vein.

Slide 14

Here is a clip of the normal appendix on ultrasound. We see the large cecum followed by the formation of a blind ending tubular structure.

Slide 15

During your scanning you will inevitably run into small bowel and large bowel.

The small bowel is often peristalsing and has lumen contents moving around. In the upper image we see a luminal structure with intraluminal contents. I’d say it is actually difficult to identify small bowel in a still image**, so here is a clip that shows small bowel peristalsing and with luminal contents**.

The large bowel classically has a “dirty air” pattern as shown in the lower image. It looks this way because the ultrasound beams cannot penetrate the air in the large bowel, so we are really only getting representative images to the level of the bowel wall.

Slide 16/17/18/19

The primary criteria for acute appendicitis are non-compressibility and diameter > 6mm.

In this clip we see a portion of the appendix that is dilated > 6mm and non compressible. The hyperechoic structure (aka: white) in the middle of the lumen is an appendicolith.

And here is another example, we see a long axis view of a dilated, blind ended non compressible tubular structure. And, what do you think is that hypoechoic area at the bottom of the screen??? Although it is poorly visualized in this case (there are some better examples later), this presents the iliac vessels.

And here is one final example showing a cross section of a dilated non compressible appendix. An appenddicolitih is seen again the lumen as well.

I really want to drive home this point. The main findings of appendicitis are non compressibility and dilation >6 mm. These findings are diagnostic of appendicitis with sensitivity and specificity similar to CT.

Slide 20

Ok, now that we’ve concluded that the primary findings indicating appendicitis are non compressibility and diameter >6mm, no let’s talk a bit about a bunch of other findings that are certainly significant, but should be thought of as secondary signs.

These include an appendicolith, which we’ve seen two examples of already, free fluid around the appendix – which often indicates rupture, mural hyperemia on Doppler imaging which is secondary to increased blood flow to the inflamed tissue, hyperechnogenicity (aka: bright) local mesenteric fat which is analogous to fat stranding on CT scan, and the target sign which is due to hyperechoic mucosa/submucosa surrounded by a hypoechoic muscularis.

These findings are all important, but I really want you to take away the non compressibility and diameter > 6 mm.

Slide 21/22

Here is an example of an acute appendicitis, what do you see on assessment of the clip.

The first thing we notice, is a large hypoechoic fluid collection. Within this collection is a blind ended dilated tubular structure. We can also see the iliac vessels posterior to this structure which the sonographer demonstrates with Doppler imaging. They then go on to demonstrate non compressibility and a “ring of fire” sign indicating mural hyperemia.

Put together, this is clearly a case of perforated appendicitis.  
Let’s watch through the clip one more time to highlight these findings.

Slide 23/24

Here is another example. We see the psoas and iliac vessels to start with, followed by the appendix, then a large fecolith, and then the appendix is followed to it’s tip.

This is a nice example that the appendix can be curvy, and you may not see the whole tubular structure in one image as has been the case in many of the pristine examples I’ve shown you. Just something to keep in mind.

And here is a still of the beginning of that clip showing the iliac vessels and the ultrasound appearance of the psoas muscle, both of which are excellent landmarks to aid in finding the appendix.

Slide 25/26

Here is another interesting example, I’ll give you that this is an A-line pattern, this is a normal finding in the lung. What do you think it represents in the abdomen? I suspect many of you correctly identify that this represents free air, which almost certainly means there has been intra-abdominal perforation.

Slide 27

And in our last example, in addition to acute appendicitis, this clip does a nice job showing hyperechoic local mesenteric fat and a clear target sign. It also shows the iliac vessels nicely.

Slide 28 interpretation

So now that we know what to look for, how do we interpret our findings and what do we do when the whole appendix is not visualized, or the appendix is not visualized at all? In real life medicine, the question often becomes, “Do I need to do a CT scan?” And if the patient is a teenager, the risks of an abdominal CT scan radiation exposure are certainly not insignificant. So this comes up often.

As previously mentioned, about 1/3 of the time you will see the appendix well, 1/3 of the time it will be partially seen, and 1/3 of the time you just won’t see it at all.

When all relevant structures are visualized, that is to say, you see the appendix originate from the cecum and track it to it’s tip and are able to comment on primary and secondary findings, THEN this ultrasound scan has sensitivity and specificity equal to CT scan. This is true ONLY if you see all the structures.

If you are able to see parts of the appendix, but cannot fully evaluate it in terms of compressibility and diameter, then look for secondary signs. If there are secondary signs, then the patient should probably get a CT scan.

Finally, if you don’t see the appendix what does that mean? Well, it’s probably not a ginormous perforated appendicitis (else we would have seen it), but how far can that line of logic go, and how does integrating this finding with other aspects of the clinical presentation? What if the patient is a soft call for appendicitis in the first place? This is an ongoing area of research and no conclusive practice has taken hold, but basically if you don’t see the appendix and the patient doesn’t have a white count or fever, then it’s probably not appendicitis. There are some other signs/symptoms that can be taken into account as well, and scoring tools exist to help with these decisions.

So, that’s the long winded way of saying that in the setting of non-visualized appendix, if the patient has a lot of S/S for appendicitis then they probably need a CT, otherwise probably not.

Slide 29

So, in summary, consider ultrasound as a first line diagnostic test in selected patients. Then use the linear or curvilinear probe to scan over the point of most tenderness. Look for a blind ending non peristaltic tubular structure. If it is non-compressible and >6 mm this is consistent with acute appendicitis. And finally, integrate your ultrasound findings into the overall clinical picture to formulate a plan for your patient.