RYAN HUDSON: Over the next 15 minutes, I get to talk to you about ultrasound in orthopedics. I have no disclosures to make. My goals are really to introduce musculoskeletal ultrasound, talking about background and scanning technique, and then I'll review normal structures with you. Give you an appreciation for what these look like under ultrasound. And then I'd like to give you some examples of how this is being used, both for diagnostic purposes as well as for therapeutic purposes with guided injections.

So let's start by taking a look at the history of ultrasound. Ultrasound-based technology was first introduced in the early 1900s, so after the Titanic sank, and we had the development of sonar technology. But it wasn't used in medicine until the '50s and '60s, where it was largely used in obstetrics. Looking to see where it was used in musculoskeletal medicine, I found the first journal in 1958. But at this time, the image quality is very poor for muscle skeletal structures. And it remains so for the next three or four decades. I'd say probably in the last five to 10 years, we've had an improvement where we can now have higher resolution in these ultrasound images that allows for visualization of muscle skeletal structures-- tendons and ligaments, et cetera.

So what we've gone, essentially, is from the static snowball to high-quality images. And ultrasound itself has many attributes. One is that it's point of care. You can get new information very quickly to make decisions. It's relatively inexpensive when compared to other imaging modalities. It's easily tolerated by the patient. No ionizing radiation. It has a dynamic-- it allows for a dynamic exam, whether or not someone is having something that's snapping or popping, and you can take them through that range of motion while they're being imaged. Or, perhaps, doing a stress test. For example, if you're worried about the ulnar collateral ligament in the elbow or angle sprain in the knee, and you want to really grade how bad the injury is, you can do a stress under ultrasound. Also you've got contralateral normal readily available. And I often will take advantage of that. And then it also allows for procedures and needle guidance.

It does have some drawbacks that I want to share with you. One-- and probably the primary drawback-- is that the ultrasound is limited. It's not able to visualize things deep to bony structures. So those sound beads essentially hit the bone cortex and will bounce back and give a very bright-- what's termed as a hyperechoic or bright white image. But we don't have any information deep to that. And so because of this, we cannot view interarticular pathology. For example, the cruciate ligaments in the knee. The menisci. The glenerohumeral labrum. All of those, ultrasound is not going to provide useful information.

Also, it's worth mentioning that this is a user-dependent imaging modality, and it differs from some of the other imaging modalities for that reason.

So briefly, on training for musculoskeletal ultrasound, there's a couple avenues that you could take. You could get your whole practice accredited through the American Institute of Ultrasound in Medicine. Or an individual can get certified through the American Registry of Diagnostic Medical Sonography. And these are similar processes, where basically you do a large number of diagnostic scans. You prove formal training. And then you take an exam. Also, a lot of specialty boards are in the process of incorporating this into their regular board exams. Emergency medicine, I believe, was the first to do so. But other fields that are using muscle skeletal ultrasound such as rheumatology, sports medicine, kind of have an ongoing process of incorporating into their boards.

So on this slide, this is a basic picture of how ultrasound takes place in acquiring an image. As you can see on the top left here, the probe is positioned to-- I gave you an example of the supraspinatus. And so the probe is positioned in a long-access view, or in a corona plane of that supraspinatus. And there in the middle slides are illustrations where you can see where the image is being taken place. And then the corresponding ultrasound image is on the right side. And so you can see the supraspinatus as it inserts onto the greater tuberosity onto the superior facade of the greater tuberosity. With the top images being coronal plane, and then the bottom images are the sagittal plane. So the sagittal plane is going to give you the anterior to posterior information, whereas that coronal plane is the medial to lateral information.

Doppler is an important property that's used in ultrasound to provide more information. And this pertains to the property that sound frequencies of objects change as they move towards or away from you. Think of a police car as it passes you, how the sirens will change in frequency. And so color Doppler, it's red if it's toward you. It's blue if it's a way. Power Doppler is more sensitive to color Doppler. The physics are fairly complex. But it does not give information regarding direction. And where this is used the most, of course, are in blood vessels, looking for DVTs another vascular studies. I use it in my clinic all the time, especially with needle guidance, and making sure that there's a clear pathway of the needle, and there's no collateral blood vessels in the way. It's also useful for neovascularization, tendonopathy, or for masses, as malignant masses are much more likely to have neovascularization. And for hyperemia, for synovitis, for rheumatologic disorders.

So here in this slide, you can see some normal structures and what they look like under ultrasound. The top left image here is the Achilles tendon. And this tendon is-- some characteristic features of tendon is it's a relatively hyperechoic structure, so it's pretty dense. It's going to reflect those sound beams. It's homogeneous. It's fibular. And you can see that it attaches there to the calcaneus, which, on the other hand, is a hyperechoic structure that's going to reflect almost all of the sound waves. And we don't have any information deep to that. Instead, we have a posterior reverberation artifact.

Ligament appears similar to tendon. This is an example of the anterior talofibular ligament, here on the right side of the screen. It's also hyperechoic, fairly dense structure. But it's much more compact. It's harder to identify the individual fibrules that we see on the tendon.

Muscle, on the other hand, a lot more water content. So this is more hypoechoic. There's more throughput of those sound waves. This is an example of calf musculature taken in a both long and short access. Which we do when we evaluate any structure-- take two orthogonal views. So here in the long axis, you see the nice pinnate pattern of the muscle tissue. And then when you turn your probe 90 degrees to get a short axis view, you get what's called a starry night appearance of these fibroadipose septa, which are very hyperechoic.

Peripheral nerves have a very characteristic appearance. They appear like a honeycomb. And that's due to the organizational structure of the perineurium-- the bundles of individual fibers. And so this is an example here of the median nerve in the carpal tunnel seen in short axis view.

So moving to give you some pathology examples. And musculoskeletal ultrasound has a lot of diagnostic applications, in sports medicine, orthopedics. A few examples would be tendon tears, such as the rotator cuff, patellar tendon, Achilles tendon. All those are readily evaluated with ultrasound. A tendonopathy, or what is known as chronic tendonitis, where it's changes within the tendon substance. Where you get mucoid degeneration. There's not necessarily inflammation, but instead, you can have a painful tendon. And you can see features of this on ultrasound. And I'll show you an example in a bit.

Ligament tears, muscle tears. In fact, ultrasound is more sensitive at picking up early myositis ossificans than x-ray is. Hematomas and other fluid-filled structures such as ganglion cyst, peripheral nerve compressions. And then things that are subluxing, such as foot subluxing nerves and subluxing tendons.

So in this slide, I want to give you an example of a tendon tear. And so this is a common tendon-- I showed you how we acquire the supraspinatus views in an earlier slide. This is somewhat of a busy slide. I'd like to explain it to you. On the top two pictures, we have a long and short axis view of the supraspinatus In the middle, we have some diagrams to kind of show you what's going on with those structures. So you have the humeral head in superficial. That is the supraspinatus RYAN HUDSON: Over tendon in superficial. That is the deltoid. And then on the bottom is also the patient's contralateral shoulder.

And so looking at these pictures, I'm sure that everyone can appreciate that there's a difference between the top and the bottom. His right shoulder was symptomatic. And as you can see there's an absence supraspinatus superspinatus tendon. And so this is an extreme example on the spectrum of rotator cuff tears, because this is a complete, full thickness tear that's been retracted. But kind of going back to Doctor Stacey's example of Larry, Curly, and Moe, you can see that the humeral head here is bald, like he was showing in the MRI. And it looks very similar. You can see that this is the deltoid which is the same, that corresponds to this. And then the supraspinatus here is completely absent in the symptomatic side.

Tendonopathy. I talked a little about this. I think this is a very common problem in the aging population and in an active and athletic population. Examples are tennis elbow, golfer's elbow, jumper's knee, Achilles tendonopathy. I see a lot of proximal hamstring tendonopathy. And this is what this looks like on ultrasound. So the patient's symptomatic side is on the right, and his asymptomatic side is on the left. And I'd like to talk with you through these ultrasound images. So the asymptomatic side, again, this is very homogeneous. Nice linear structure with the fibrules. Whereas the symptomatic side, it's quite edematous. And I've taken measurements so I can compare the two. I've sent this patient to physical therapy first, and we saw that it got better with physical therapy. We had quantitative improvement on ultrasound. So it was quite edematous. Its hypoechoic, or darker, as well as it has neovascularization. And so that's important, as we think that these new vessels are potential pain generators. And a lot of our therapy is actually directed at some of those new vessels within tendonopathy.

Here's an example of a ligament tear. This is anterior talofibular ligament again. And you can see on the right side is the pathology, where that ligament is swollen and discontinuous. And then this would be a case where doing a stress test, a dynamic evaluation, could be helpful, and really quantifying this as a grade two or grade three sprain of the anterior talofibular ligament.

This is what ganglion cysts look like on ultrasound. We know that they're most common in the wrist. This is an example within the foot. He had several ganglion cysts overlying the rays of his extensor tendons. And so these appears as very dark structures. They're anechoic, because they're fluid-filled. They're compressible. And then if you put Doppler on them, they're not going to light up with Doppler. So we know that they're not associated with any vasculature.

This is an example of peripheral nerve compression on ultrasound. This is the most common one-- carpal tunnel syndrome within the wrist. And you can see on the long axis view here, on this top left slide, what's called the notch sign. As you can see, compression where the nerve will change in caliber. On the short axis view, you have that honeycomb appearance here on the bottom right slide of peripheral nerve. And with carpal tunnel syndrome, this nerve will be much larger than on an asymptomatic side.

One example of a dynamic application is looking for things that snap or pop. So I have a case here of a snapping hip syndrome. So we know there's different areas that the hip can snap. But one of them would be internal extra-articular snapping hip, where that iliopsoas is snapping over the pelvic brim, or the iliopectineal eminence. And so basically, I'm using ultrasound while doing a physical exam, and taking the patient from a flexed, externally-rotated view into an extended, internally-rotated movement. And with this, you can see, you can feel a clunk underneath the probe during that maneuver. So we'll see if we can play that video. But this is the iliopsoas. And basically it clunks and disappears as I'm going through that maneuver. So that can help really determine, is this snapping coming from the tendon, or is it coming from something more interarticular?

So briefly, just a few more slides on procedures. What's the rationale for using ultrasound for procedures? It's going to increase accuracy and thereby increase efficacy. It can be used for diagnostic injection. So if we're concerned about a very specific pathoanatomic location, I oftentime will inject Lidocaine into that structure to see if that improves the patient's symptoms. Then it's going to improve safety by avoiding any nerves, blood vessels, as well as avoid intratendonous injections, because we know that cortisone within the tendons is very bad for tendon health and can lead to necrosis.

There's this slide is just a table where I chose some-- there's a lot of literature out there comparing different methods of doing injections, whether you do it palpation-guided, ultrasound-guided, with fluoroscopy, et cetera. This is some studies for shoulder injections. And, as we would expect, ultrasound is going to have more accuracy than palpation-guided for some of the structures that are a little bit harder to reach with palpation guidance, because perhaps the landmarks aren't readily available. So to do a hip injection, which is a pretty common injection that is done under ultrasound, is a nice alternative to fluoroscopy, because it's a pretty easy injection under ultrasound. You basically place the probe at the axis of the femoral neck, as you can see in this upper right picture here. And the needle path is directed here at the junction of the femoral head and femoral neck. If we play this video, you're watching in real time flow occurring. You can see the bubbling occur right in this region of the injection. Then the capsule will slowly distend with the injection, so we know that you're in the right location.

Baker's cyst is another place that ultrasound can be very helpful to aspirate. We know Baker's cyst is as a bursa, actually, in between the medial head of the gastrocnemius and the semimembranosus. and so on ultrasound, they tend to look kind of comma-shaped, so this is what that looks like. Anechoic. Then guiding your needle, you can carefully aspirate all regions of the cyst, then inject some cortisone in there.

So lastly, for tendonopathy, there's a variety of different types of nonsurgical injections that we could use. So this is back to the Achilles tendon. You see the fusiform pattern of this tendon here in the upper left. You do a short axis view, you get these anechoic clefts within the tendon that's associated with tendonopathy, and those are essentially your target sites for the injection. In this case, I'm injecting PRP in that site.

Thank you very much for your attention.