

ct and mr of spine infections for about the next half hour our learning objectives are pretty straightforward we're going to teach you how the pathophysiology and particularly the vascular anatomy help to determine the imaging appearance of spine infections we'll learn to critically assess which imaging options offer the greatest sensitivity both for initial diagnosis as well as post-treatment assessment and this is a real bugaboo for me probably for you as well to be able to differentiate spine infection from common mimics most notably degenerative disease now my colleagues in infectious disease are able to differentiate extremely easily they just order a biopsy in everybody so it's really my self-interest that has led me to try to refine this diagnosis and try to really differentiate spine infection from the more common degenerative disease now as you'll see when i discuss the vascular anatomy primarily what we're speaking about is a disk space infection and that's an inflammatory process involving the disc and adjacent vertebrae with extension typically to the epidural space and paravertebral soft tissues and people use a lot of different names and i would advise you not to use the term disguise if you think it's infection say it's infection if you think it's in the disk tell them it's in the disc if you think it's in the vertebral body tell them it's in the vertebral body but if you think it's infection say infection the major pathogen i'm sorry the major pathway is hematogenous spread to the spine from another infection like a urinary tract infection or a pneumonia staph aureus is the major pathogen accounting for well over 50 percent of cases but pseudomonas is a major player particularly in the iv drug abuser population and risk factors in addition to iv drug abuse include age over 50 infection in another part of the body and diabetes let's have a look at the vascular anatomy so as i animated before the typical spread is arterial to the spine the distal vessels with slower flow are at the end plate and or the intervertebral disc and so the typical pattern of involvement that we see on

imaging is disk space involvement and involvement of the adjacent end plates now kids and adults are a little bit different and i'm going to show you this differentiation in the child vascular channels cross the growth plate so the disc is relatively vascular and the primary infection from this hematogenous spread is within the disc but then it spreads very quickly to the adjacent vertebral end plates in the adult the disc is relatively hypovascular and so the initial infection is in the vertebral end plate or end plates with secondary spread usually within a few days to the intervertebral disc once the infection becomes established within the disc space there is venous spread to the epidural space sometimes giving you an epidural phlegmon sometimes giving you an abscess and i'll show you how to differentiate those and also to the pair of vertebral soft tissues unfortunately the clinical picture of a disk space infection is pretty non-specific it's progressive spine pain constant no relief with rest there's a neurologic deficit and only a small minority i think that looking at the sed rate or the c-reactive protein is useful because at least according to my spine surgeons if your sed rate is not elevated you really don't have a significant spine infection the problem is if you have infection somewhere else in the body the sedrate is going to be elevated whether you have a spine infection or not blood cultures are pretty variable i think a lot of these blood cultures are taken after uh one or more of the patient's infections are at least partially treated and so these symptoms are very non-specific well is plane film any good i mean a lot of us will screen for back pain with a plane film and in this case if you really zero in you'll see that there are poorly defined end plates and remember that vascular anatomy that i taught you that's the first place where you're going to look you can see a nicely defined end plate here you can see the sclerosis you can see the sharp margins you come down here and you've lost that and you'll be able to see that on plane film you'll be able to see that on ct and i'm going to show you how you can see that on mr

as well but even those early findings at least on plane film will lag two to three weeks after the clinical symptoms as the osteomyelitis progresses you can see that there's more bone destruction and later findings include bone sclerosis and progressive loss of stature this is obviously late in the infectious process chronic osteomyelitis will often heal with ankylosis and kyphosis as i've shown you on this plane film exam let's move then to ct well we know that we should have involvement of opposing end plates and an abnormal disk space and i almost don't have to point out the findings here on this sagittal view notice the well-defined end plates here there are virtually no end plates here and certainly the intervertebral disk space is involved you can see the paraspinus involvement even on this non-contrast ct obviously the epidural component is a little bit more challenging and contrast can really really help you if you're going to do a ct evaluation chronically here is that ankylosis and kyphosis that i showed you on plane film but one of the things that i really like are the 3d reconstructions because you can see the calcification and ossification that has occurred in the soft tissues as a result of that venous spread resulting in the ankylosis that we see okay the real workhorse of course is mr so i'm really going to focus on mr findings in spine infection let's just start with a t1 where are we going to look we're going to look at the disc we're going to look at the vertebral end plates and you can see here that we've got some low density and at least a questionably abnormal disc let me blow that up for you so you can see a little bit better well-defined end plate well-defined end plate you come down here where's my black line where is my end plate where's my end plate okay so at least on a t1 one of the areas where i go is to look at those end plates now in this case you can probably see that we've got an epidural component and we've got a paraspinous component as well we can see those components a little bit better on the t2 we're also seeing that there's t2 prolongation or t2 bright signal involving these

vertebral bodies and kind of plus minus within the disk disks are a little bit difficult because sometimes these disks are degenerated and when they're degenerated you just don't have very many water protons to give you much of a signal you can certainly see the paraspinous component and a little bit of epidural component perhaps a little bit better seen here off axis now as i told you my major problem is differentiating spine infection from modic type 1 changes so i decided to review the modic type 1 changes and you know for historical interest i went back to mike modic's original article from the 1988 radiology and you know if you look at the quality of these images thank god we've come a long way but what dr modic pointed out is in these modic type 1 degenerative changes the end plates are t1 dark and you can see that here but then they brighten up on t2 the disk space is dark on t1 dark on t2 so i've put together a little chart here and we're going to expand this chart as we add various imaging sequences and you can see that it's pretty difficult to differentiate infection from modic type 1 changes just using a standard t1 and t2 really about the only place that you can focus is to look for increased t2 signal intensity of the disk and even that is not always present but that's where you want to focus when you're looking at least at a non-contrast mr okay so let's add contrast we'll go back to that cervical spine case that we could see and you can see that the disc and vertebral bodies show contrast enhancement and the contrast enhancement really can help you with the epidural and paraspinous components of the infection let's look at a lumbar case we'll start out with a t1 a t2 and a stir one of the reasons i show this case is if you're really trying to go quickly i would rather look at a stir than at this t2 everybody buy in on that i think you can see the t2 prolongation a little bit better because of the inherent fat saturation in the stir imaging so if you're trying to go quickly or your ed is asking for a lot of total spines what you might want to do is do t1 and stir and

maybe a few other sequences like a contrast enhanced let's look at the contrast enhanced here is our t1 you can see the low signal and then that kind of fills in on the post contrast notice though that the disk space looks dark here and boy to my eye it still looks dark here so let's enter this data into our chart and see if contrast enhanced helps us well it helps us some of the time if you see the disc enhanced it pushes you toward infection but the problem is that it's not always present so that is not as much help as we would hope this is a pretty easy diagnosis i think everybody would be able to diagnose the epidural component the abnormal disc space the abnormal vertebral bodies in the paraspinus component we can add a t1 with fat saturation and this really helps me to appreciate the circumferential nature of the epidural phlegmon in this case i remember i told you that i was going to teach you how to differentiate phlegmon from abscess phlegmon will show you solid enhancement abscess will show you only peripheral enhancement let's look at an example this is obviously a different case we're looking up here in the cervical spine and you can see that there is some abnormal brightness post contrast within the c2 vertebral body you see a small anterior epidural collection with low density this is the abscess and this is surrounding enhancement so this is an example of an epidural abscess now in this case we also went ahead and got diffusion-weighted imaging one of the things that we noticed is that our trainees at the university of arizona were having a lot of trouble with these spine infections and they basically are our first line at night and when it's three in the morning i want that first line to be intact making good diagnoses and being pretty confident about their diagnosis so we started to do diffusion weighted imaging and these diffusion weighted images are not the prettiest things on the block but notice how nicely you can see the restricted diffusion and if you really squint you can even make it out on the adc that shows you the epidural abscess in this patient now according

to the literature and I say according to the literature because in my hands this was a little bit difficult. Diffusion-weighted imaging can reliably know about that differentiate motor type 1 end plate changes with no restricted diffusion from the abnormal end plates in a disk space infection. Well, this sounds pretty good but unfortunately people were turning up some restricted diffusion even in the Modic type 1 changes and so I've added this to the chart but I've sort of given you a little sideways arrow here that yeah you should have restricted diffusion within the end plates sometimes that occurs within the disk but not always so can we refine this a little bit more and a few years after one of my former fellows actually published this paper and he stated that a third of the patients with motor type 1 changes in T2 prolongation within the disc are really degenerative disease rather than infection and that's the conundrum we've been dealing with so he applied diffusion imaging and describe the claw sign and it's important to really wrap your head around this claw sign because it may not be that intuitive. It's defined as well-marginated linear regions of high signal within the adjacent vertebral bodies not necessarily right at the end plate and a positive claw sign is degenerative disease not infection. Let's look at some pictures. This is from Dr. Patel's article you can see the you know maybe it's Modic maybe it's infection type changes and here is the claw sign. Notice that the end plates aren't so much involved but this band or linear area of restricted diffusion within the adjacent vertebral body marrow. This is a positive claw sign. This implies degenerative disease. Okay and then he went through and he had different classification systems. This is about what we would expect in a disk space infection: abnormal disc, abnormal vertebral bodies, abnormal end plates. This is the claw sign: no restricted diffusion within the disc and then these linear areas of marrow involvement that define the claw and unfortunately a lot of cases fall in an indeterminate range and what they did is they put together an algorithm

and this is really the algorithm that i use so patients symptomatic symptoms are non-specific so we're not quite sure what to do with those but it could be a modic pattern what do we do we look at the disk is the disk bright if it's not bright infection is unlikely if the disk is bright we haven't solved our problem yet we can throw diffusion weighted imaging into the mix we can look for the claw sign positive claw remember is infection unlikely most likely degenerative disease if there's an absent claw then you're kind of stuck saying yep this could be disguised and the patient usually goes to biopsy okay here is a bit of a problem case have a look at the c67 level the disc is t too bright it enhances but the end plates are dark and not enhancing what are we going to do well of course we are going to try to do diffusion this is one of my cases of a claw sign we were able to avoid biopsy in this case this is degenerative disease another sign that might help you out is the psoas sign and the problem of course is that lumbar disguise osteomyelitis has characteristics that overlap with non-infectious causes so look for psoas hyperintensity pretty easy to pick this out so is hyperintensity so is hyperintensity no hyperintensity no hyper intensity this is infection this is degenerative disease but a useful sign even on a non-contrast study let's now look at the time course of spine infection and i like to follow this on a contrast-enhanced t-wat here we've got multiple components abnormal disc abnormal vertebral bodies abnormal epidural abnormal spinous we did a biopsy following the biopsy antibiotic therapy for two weeks and look what's happened there's now no abnormal epidural enhancement perispinus has decreased but there is persistence of enhancement here within the vertebral bodies and within the intervertebral space so if you're getting a follow-up where is your eye going to go to be efficient what you should be doing is starting your interrogation by looking at the epidural space and looking at the paraspinus soft tissues that's going to save you some time that's going to increase your accuracy

let's look at another case here we've got a multifocal epidural abscess 10 weeks this time of antibiotic therapy obviously that was a pretty nasty infection and look what's happened the epidural component is much reduced perhaps cleared away so your eye should go to that epidural space even when you have abscess if you have prolonged antibiotic therapy you can clear that infection so if possible follow the contrast enhance t1 use fat saturation earliest changes epidural and paraspinus last to show change are the vertebral bodies and if you think about it these changes reflect the vascularity of the tissues involved so it all makes sense now i talked about hematogenous spread but clearly you can have spread from an adjacent organ abnormal chest x-ray you can see on the ct you've got a lung abscess and it's extending here to the spine classic findings of a disk space infection contrast helps you can see the epidural findings and you know more of the same facet injections you know a lot of times we don't pay as much attention as we should to the facets in this case it was hard to ignore and then we looked at the axials and you can see that there's a lot of infection going on here centered on this facet joint and of note there's a lot of epidural disease as well so in somebody where you're looking for spine infection i'm looking at the disc spaces first i'm looking at the vertebral end plates but before i put this case away i look at the facet joints as well let's look at a case of tb now tb is a real fooler remember i told you that in hematogenous spread to the spine we go to the disk we go to the end plate and then we spread because there are proteolytic enzymes and the proteolytic enzymes quickly colonize the disk in the adult and the end plate in the child well what if you're dealing with an infection that doesn't have proteolytic enzymes like tb it's going to stay in the bone it's not going to go to the disc and it's not going to cross the disk space to involve adjacent vertebral body so you get a picture like this and i'll tell you the first thing i think about when i see something like this is probably not tb i'm thinking



about a malignancy and i'm thinking about a malignancy right you've got marrow replacement end plates look pretty good uh intervertebral discs not bad hey we all know that malignancy can spread to the paraspinus regions and a lot of these cases go to biopsy so many of these cases go to biopsy that i do the spine biopsies at my place and so when something that looks like this comes in and it says you know evaluate for neoplasm i put on a tb mask and i ask my team to put on a tb mask as well because occasionally something that's advertised as a neoplasm comes back is tb okay you can look at the t2 i don't know still looks like uh neoplasm mean look at how nicely defined those end plates are and even contrast doesn't help you all that much okay i'm from arizona so i got to show you a case of coxy and coxy is a great mimic um if you're not living in arizona or california you're probably not going to see very much of it which is actually going to make your life easier abnormality here within the vertebral body you know god only knows what that is it turned out to be coxy here it looks like we've got something in the spinal cord god only knows what that is it turned out to be coxy this one's a little easier you can see there's massive lung involvement it has extended to involve the spine it's involving rib here i think most of us would put cocci pretty high in our differential but it can look like just about anything it can be pretty messy speaking of a messy case i'm going to show you one of the really nasty ones that i've seen here a lot of times we'll get a ct within the first few days following surgery just to make sure the hardware is in good position and you know graft material hasn't migrated and all that i mean one question i would ask is okay man you operated on this level and everything looks good was there some reason you didn't want to operate here maybe they'd done a flexion extension and this guy was fused here that so there wasn't too much they could do in any case we gave him a clean bill of health great but after 17 months the patient returns obviously not doing well disk space involvement end

plate involvement what are we dealing with here i was certainly very concerned about infection sorry so what they tried to do was a laminectomy and a kyphoplasty and that didn't really turn out to super well you can see the cement here i guess they were able to get some stabilization but it didn't really help the infection all that much you can see here that there is some stenosis worsening spinal stenosis the infection is just going crazy and they ended up with a major reconstruction here and notice that they had to dig out all that cement so sometimes these turn out to be pretty gnarly cases well what have we learned we reviewed the plain film ct and mr appearance of the common spinal infections and we realized that those don't always allow us to differentiate from modic type changes particularly modic type 1 degenerative changes so we added the clause sign which it means you need to do diffusion and we added the psoas sign which means that i usually do it on the axials you need to look carefully at the t2s we talked about how the vascular anatomy determines the initial side of infection a little different in kids and adults and then the spread of infection i illustrated the time course of spinal infection you know particularly where do you look to see the very earliest changes and you're going to look in the epidural space and you're going to look at the paraspinal soft tissues and then we analyze the components of the spinal infection talk about where those early changes might be seen thank you so much for your kind attention