

Dr. Jason Barnes:

Hey there. Welcome to another episode of ENT in a Nutshell. My name's Jason Barnes. And today we are joined by Dr. Matt Carlson to discuss lesions of the petrous apex. Dr. Carlson, thanks again for being here.

Dr. Matthew Carlson:

Thanks a lot for having me.

Dr. Jason Barnes:

Now, today, we're talking about an anatomic area. We're doing things a little bit differently. We usually talk about a specific disease process and systematically work through it. But today we're talking about an anatomic region that petrous apex. So Dr. Carlson, just to start, can you tell us why does the petrous apex matter? Why should we talk about it?

Dr. Matthew Carlson:

Historically, petrous apex was involved in the pre-antibiotic era with infection, which would result in a lot of patient morbidity and mortality. It's an area that's difficult to examine externally based on a physical examination. It's also an area that's very difficult to access surgically to remove certain lesions of the area. And it's an area that to be a good clinician or a good otolaryngologist, it's beneficial to understand the different imaging characteristics, because there's a whole host of different pathologies that can affect this area, all the way from completely benign anatomical variants, to benign neoplasms, to malignant neoplasms, and severe infections.

Dr. Jason Barnes:

Our conversation will get a little bit dense because we're going to be talking about anatomy and imaging, but we'll try to break it down in a way that our listeners can understand. Can you first talk about the definitions of the petrous apex? What defines this region anatomically?

Dr. Matthew Carlson:

So depending on how you break it down, there's five plus subunits of the temporal bone. In the petrous portion of the temporal bone is a large, more medial portion of the temporal bone. It includes or encompasses the otic capsule and many of the coursing cranial nerves and many of the foramina of the skull base as well.

Specifically, the petrous apex is a triangle with its base at the otic capsule. Based on some definitions, the base of the petrous apex is at the superior semicircular canal. Others will define it as the base being the otic capsule itself. The peak of the pyramid extends to the clivus and then it has three sides, the middle fossa floor, the medial posterior petrous wall, and then an extra temporal part that goes towards the infer temporal fossa. There are a lot of important arteries and nerves that course through it. One of the ones that is always a consideration when you're thinking about surgical approaches in particular is the course of the petrous carotid artery. The petrous carotid artery will enter the carotid canal, and then just below and anterior to the cochlea, will enter its first genu to its horizontal portion. And it's the horizontal portion that courses through most of the petrous apex, and it will pass by the foramen lacerum before it enters its second genu and it's a vertical portion.

Dr. Jason Barnes:

And a of times when conversations of the petrous apex come about, there's clinical relevance, but also board relevance to a couple of specific anatomical regions. Can you speak to those?

Dr. Matthew Carlson:

Yeah. I think you're probably referring to Meckel's cave and Dorello's canal. Meckel's cave is a potential space that houses the Gasserian ganglion of the fifth neuroganglia, trigeminal ganglion. It's bounded by an envelope of dura made from the tentorial edge superiorly and also the posterior fossa dura as it comes up superiorly into Meckel's cave. And so again, it's a potential space created by two different dura leaflets. And it's a transition from the posterior fossa to the middle fossa floor for the fifth nerve. And tumors can spread into this area of particular petroclival meningioma or chondrosarcoma.

And in this region, if a pathology involves Meckel's cave, the patient may experience fifth nerve symptoms and the fifth nerve symptoms can pick up as different symptoms. It can be facial hypoesthesia or facial neuropathy where you actually have numbness in any of the V1 through V3 distributions. You can also have a trigeminal neuralgia, which is specifically different in that you have pain and it's a lancinating electrical like pain. It's on the same side of the face, or the ipsilateral side of the face.

The other anatomical feature that's commonly asked about is Dorello's canal. Dorello's canal is a canal that's primarily formed by the petroclinoid ligament, or Gruber's ligament, as the sixth nerve courses from the posterior facet into the skull base, it'll meet with the inferior petrosal sinus and travel anteriorly. While it's doing this, it'll pass through Dorello's canal.

Dorello's canal is a sort of bottleneck area. Whenever there's infection or swelling or a neoplastic growth in the petrous apex, it's a constriction site and it can end up damaging the sixth nerve in this area. And so involvement of Dorello's canal classically results in a sixth nerve palsy. I think that thinking about these two anatomical regions can bring us to the next eponym that's commonly discussed in this area, and that's Gradenigo's triad.

Gradenigo's triad is a condition or an eponym that's used to describe inflammation or more commonly infection of the petrous apex. And it's the constellation of a sixth nerve palsy retro orbital eye pain or headache. It's often related to trigeminal discomfort or irritation and unilateral otorrhea related to otitis.

Dr. Jason Barnes:

So we talked about the anatomy specific anatomic features, and you started to talk about symptoms. Could you speak a little bit more specifically to the symptoms that can be involved with patients presenting with petrous apex lesions?

Dr. Matthew Carlson:

Yeah. So, in medical school and residency, you are always taught to localize the lesion and there are some localizing symptoms that are highly specific for involvement of the petrous apex. Sixth nerve palsy involving Dorello's canal, as we already talked about, is very specific for involvement of the petrous apex and also fifth nerve irritation. Those will be common manifestations for a person with a neoplasm, such as a chondrosarcoma, for example, involving the region of the petrous apex as well.

There are some less specific symptoms that can occur from involvement of the temporal bone in general. And those include hearing loss if there's impingement of the otic capsule or the internal auditory canal, for example you might have sensorineural hearing loss or dizziness. You may have non-specific symptoms of headache. Just with all pathologies, it could be related to the disease process, or it

could be completely independent. Involvement of the facial nerve could result in facial neuropathy or facial nerve spasm. And these would be the most common symptom presentations that could be involved with a lesion of the petrous apex.

Dr. Jason Barnes:

And sometimes patients present asymptotically. And when we look at an MRI, we start to decide what the pathology is in the petrous apex. However, there isn't always a pathology there as there are some normal variants of anatomy. Could you describe some of the normal variants of the petrous apex that we can see?

Dr. Matthew Carlson:

Yeah. That's a really good question. A very relevant question, because I'll say more often than not, I'll see a consulting clinic for an incidentally diagnosed lesion of the petrous apex. And the question is whether or not the patient needs treatment or what the disease process is. And as we alluded to earlier, the petrous apex is an area that you can't just easily biopsy, certainly not in clinic, and it requires a surgical procedure to do so. And so it's helpful if you can look at the features on an MRI, for example, to find out if it's something that you even need to biopsy or go after to begin with.

So there are some conditions of the petrous apex that are what I would consider normal variants, and certainly nothing that require biopsy and should be recognized based on a scan. The petrous apex can... So during development, the petrous apex includes red marrow that generally graduates to yellow or fatty marrow over time. And that's how most people have, their petrous apex includes some fatty bone marrow, but you can have varying degrees of pneumatization in the petrous apex as well.

So for example, on an MRI, you might have asymmetrical T1 hyperintensity from one petrous apex compared to the other, and this could be asymmetrical marrow. Asymmetrical marrow in varying degrees of pneumatization of the skull of the petrous apex occur in at least 10% of temporal bones. You can also have petrous apex effusion, which I would say is not a normal variant, but it's not an uncommon thing. So a person who has recurrent otitis media or eustachian tube dysfunction may have tracking effusion that can develop in the petrous apex. And this is also something that typically doesn't require an intervention unless it develops symptoms, for example.

Dr. Jason Barnes:

So those are non pathologic lesions. But when we start to talk about pathologic lesions of the petrous apex, what are they and how do you break them down into different categories?

Dr. Matthew Carlson:

There's a lot of different conditions that can affect the petrous apex. You can have cystic lesions, which encompass the most common category of lesions involving the petrous apex. You can have infectious lesions, which historically was the most common pathology involving the petrous apes with Gradenigo's triad, particularly in the pre antibiotic era. You can have solid neoplastic lesions involving the petrous apex and you can have other lesions.

I think it's worth pointing out here also that it's a commonly reviewed board question. And that is where in the temporal bone is the most common location have metastatic disease? And the answer is, as you might guess being the subject that we're on, it's the petrous apex. And the petrous apex uniquely contains a lot of marrow and slow flowing blood through the sinusoids of the marrow. And this is an area where you can collect hematogenous malignancy as it metastasizes and therefore for that reason

metastatic disease of the petrous apex is not overly uncommon for people with [diffusely 00:10:25] metastatic disease.

When we break down those categories against cystic being the most common by far and away. And I want you to remember this because it's commonly asked, by far and away the most common lesion, cystic lesion in particular of the petrous apex, is cholesterol granuloma. And we'll get into that in a little more detail in a bit, and there's also cholesteatoma or what we would call epidermoid when it involves the petrous apex and mucocele. Infectious lesions, again or petrous apicitis, with Gradenigo's triad sometimes, in osteomyelitis. And neoplastic or solid neoplastic lesions include meningioma such as a petroclival meningioma, a chondrosarcoma, which has a predilection for the petroclival junction, chordomas, which typically are more midline compared to chondrosarcomas, neurogenic tumors, such as a fifth nerve tumor, trigeminal schwannoma, for example, and metastatic disease as we said earlier.

And much less commonly, you can have other conditions, osteo dystrophies, abnormal bony growth, fibrous dysplasia, or you could even have a carotid aneurysm as it course courses through the horizontal segment. Again, quite rare.

Dr. Jason Barnes:

So as you said, the cystic lesions are the most common in this region. So we'll spend a majority of our time talking about these. We talked about cholesterol granuloma, epidermoids and mucoceles. Could you start by telling us about cholesterol granuloma, maybe just describing cholesterol granuloma in a nutshell?

Dr. Matthew Carlson:

Yeah. So cholesterol granulomas are again, the most common cystic lesion of the petrous apex. They're often diagnosed incidentally. Patients will often report headache or some other non-specific symptom. They'll get an MRI scan, they'll see this lesion of the petrous apex. And of course, everybody will point to that and say that's the cause, but I'll tell you that in many cases of small petrous apex cholesterol granuloma is probably not the cause of this, or said another way, removing or treating that lesion is probably not likely to improve the patient's headache.

It's commonly asked about, and you should grill this into your brain. The imaging characteristics for a cholesterol granuloma are hyperintense on pre-contrast T1 and hyperintense on T2 imaging. There's essentially no other lesion of the petrous apex that has that imaging characteristic. And again, that question seems to find its way in board questions over and over.

If you got a CT scan, you'd see remodeled bone secondary to displacement by the large cystic structure, a large cystic cavity. There's a couple different theories that I think are worth mentioning very quickly as to why they develop. The old theory is the obstruction vacuum theory where eustachian tube dysfunction results in negative pressure. And it might result in a mucosal bleed for example, and that blood in the petrous apex can create a foreign body reaction or granuloma formation.

The second theory was proposed by Jackler and that's the exposed marrow theory. And that's the idea that some of the red marrow or some of the vascular marrow in the petrous apex might become exposed by the neighboring adjacent pneumatized petrous apex. And that can create a situation where it could bleed into itself. Again, that blood product creating a foreign body reaction and precipitating the development of cholesterol granuloma.

We'll get into surgical approaches a little bit more later when we talk about just the general approach to treatment of petrous apex lesions. But I do think it's worth mentioning the treatment strategy or treatment paradigm for cholesterol granulomas. Most cholesterol granulomas today are

observed. They're often diagnosed incidentally in patients without attributable symptoms, but for the cholesterol granuloma that's growing and causing localized symptoms, and you feel like it needs treatment, the treatment is surgical evacuation of the cyst. The idea what the approaches are that you don't have to remove the entire cyst, but rather you can make an opening into it. So it can drain fluid.

There are some problems with that though. Cholesterol granuloma classically has a motor oil thick viscous material in there mixed with loculations and granulation tissue. And so just by opening into the cyst, you often don't effectively drain it. And so some people more and more will advocate for full removal of the cyst rather than just making an opening.

Dr. Jason Barnes:

So we talked about cholesterol granuloma, and as a reminder, we're talking about cystic lesions of the petrous apex. And the next one, we want to talk about an epidermoid. What is an epidermoid?

Dr. Matthew Carlson:

So whenever you have an epidermoid cyst anywhere in the body, it's given different names depending on where it's at. So if it's in the ear, in the tympanic mastoid cavity, it's called a cholesteatoma. When it's in the petrous apex, or according to a neurosurgeon, it would be called an epidermoid. And they all have the same histopathology. That is a sac of keratinous debris, surrounded by stratified squamous epithelium. And that cyst lining is the problem of the pathology in that it keeps shutting the keratin within it.

In the interest of time and keeping this concise, the main thing I want to point out in this are the imaging characteristics of petrous apex epidermoid. And the thing that you should remember is that on imaging, the diagnostic evaluation of choice is MRI with diffusion weighted imaging. And that you want to use non-echo planar diffusion weighted imaging. Epidermoids will restrict on imaging and they'll be very bright on the scan.

Dr. Jason Barnes:

So the next lesion we'll talk about our mucoceles. In my experience, we've mainly talked about mucoceles in rhinology clinic. What are mucoceles of the petrous apex?

Dr. Matthew Carlson:

Mucocele of the petrous apex are uncommon, but they do occur. It is an interesting phenomenon. If you talk to a rhinologist and they're performing a frontal sinus obliteration, for example, which thankfully it's not commonly done much anymore, but the dogma is you have to remove every last mucosal cell. Otherwise you risk developing a delayed mucocele later. So it's trapped secretions. You have these mucus secreting cells and they don't have anywhere for the mucus to go. And it basically builds on itself.

It's interesting that the mucosa of the temporal bone is inherently different. The development of a mucocele is exceptionally uncommon on the temporal bone, both either spontaneously or following surgery, for example. But uncommonly, you can develop a mucocele of the petrous apex. On imaging, the features of a mucocele are ISO intense on T1, hyperintense on T2, and then more of a rim enhancement surrounding the mucocele on T1 plus gadolinium. And on CT scan you'll have remodeling and loss of the bony septae in the center of the lesion. So it's expansive and pushes. And the treatment for a mucocele is generally surgical, a resection of the cyst cavity.

Dr. Jason Barnes:

We're done talking about the cystic lesions, which again, comprise the majority of lesions of the petrous apex. I next wanted to move on to the infectious lesions, apicitis and osteomyelitis. Can you speak about petrous apicitis?

Dr. Matthew Carlson:

Petrous apicitis is I would say largely of historical interest. It was a very common condition in the pre-antibiotic era, and it would result in inflammation with or without an abscess formation in the petrous apex. And with that, you can have what we discussed earlier, Gradenigo's triad, which is sixth nerve palsy, retro-orbital eye pain and otorrhea related to infraction.

It will present just like what you might expect an abscess to present with. It'll result in T1 hypointensity, hyperintensity on T2, and a rim enhancing lesion on gadolinium, or the lesion might be heterogeneously enhancing throughout the entire lesion if it's primarily granulation tissue. CT scan will show a surrounding bony destruction.

Dr. Jason Barnes:

And moving on to the next category, solid lesions of the petrous apex. Can you give us a comparison and contrast of the different lesions here and how they would present on imaging?

Dr. Matthew Carlson:

So I think beyond just getting into the very specific details of each pathology, we can present some concepts about imaging for different pathologies that apply to not just the petrous apex, but common solid neoplasms of the petrous apex include meningioma, trigeminal schwannoma, chondrosarcoma, chordoma, and then malignancy.

When we talk about meningioma of the petrous apex, we're typically talking about a petroclival meningioma, or very large lesion that may involve the posterior fossa or the middle fossa or span the two areas and it commonly involves Meckel's cave. It usually doesn't have a considerable component going into the bone, but it can. And you can also have a very infiltrative meningioma that really does invade the bone that could be difficult to diagnose radiographically. But just for a broad concept, meningiomas are hyperintense on T1 post contrast. In general, they're very homogenous. So they don't have cystic heterogeneous appearance that schwannomas have frequently. They're hypo to isointense on T1 and they tend to be iso to hyperintense on T2. And some imaging features that are very characteristic for meningioma are the dural tails. And that can be again, anywhere. It should be a buzzword for you. Intratumoral bone formation. And then hyperostosis of the base of the tumor. Those are all features that can occur with meningioma.

When we talk about trigeminal schwannoma or any schwannoma for that matter at the skull base, they'll tend to be dumbbell around constriction points. And so a trigeminal schwannoma, if it starts in the posterior fossa, might constrict around the region of Meckel's cave and then expand again, and you can have a dumbbell appearance. This same sort of behavior occurs in, for example, jugular foramen schwannomas as well. You can have a large posterior fossa component that constricts at the pars nervosa. And then once again expands in the soft tissues of the neck. So if you see a dumbbell lesion of the petrous apex, you should definitely consider trigeminal schwannoma. Schwannomas demonstrate a more heterogeneous, but avid contrast enhancement on T1 post contrast, and on T2 they tend to be isointense or hyperintense.

The third lesion and the fourth lesion that we'll commonly kind of group together and try to distinguish from one another are chondrosarcomas and chordomas. The main distinguishing feature that separates these two is the epicenter of the tumor. So if you kind of look at the entire tumor and you

say, well where's the center of that tumor, a chondrosarcoma should be eccentric. It should not be a midline lesion most of the time. And it's usually centered in the region of the foramen lacerum which is one of the hypotheses of where they develop from, the cartilaginous portion of the foramen lacerum or at the synchondrosis or the suture line between the temporal bone and the sphenoid bone in the clivus. That's in contrast to chordoma. Chordoma more commonly are midline lesions that can involve the clivus, the sphenoid or anywhere in the midline neuro axis.

So I think if you remember those concepts, you'll be able to distinguish a lot of these neurogenic tumors, not only in the petrous apex but also in other areas of the skull base.

Dr. Jason Barnes:

So we've talked about the imaging characteristics and trying to formulaically diagnose these lesions. What's your approach to the treatment paradigm regarding these lesions?

Dr. Matthew Carlson:

So I think the major fork in the road when you're considering management is treatment or non-treatment. And so you have to distinguish what we would consider benign variants, anatomical variants, that don't require any further attention. And those would be asymmetrical pneumatization, asymmetrical marrow of the petrous apex. And I would even start to group petrous apex effusion, it very rarely requires any intervention. And those things are almost always universally just observed.

Lesions that kind of straddle that border between needing treatment or not, I would say the one in that area that you would talk about the most again, is a cholesterol granuloma. And as we alluded to earlier, it's the most common cystic lesion of the petrous apex. And again, hyperintense on T1 and T2. Most of these lesions are diagnosed incidentally and many of the symptoms that a patient might experience are commonly not attributable to the lesion, or it wouldn't get better with treatment. So a smaller, medium sized cholesterol granuloma would commonly be observed. If it was very large and particularly it was growing or symptomatic, then it would be treated. And the treatment for cholesterol granuloma, again, at least on a board question is a drainage procedure. You create an opening into the cyst cavity, so it can drain.

A mucocele and particularly a small mucocele could be initially observed. But if you have an expanding mucocele the general recommendation is to treat it surgically. An epidermoid just as paralleling cholesteatoma, the general rule is that you do treat these surgically if they are discovered. There's no role for radiation and generally we don't observe them if we're sure that it's a epidermoid or cholesteatoma.

The neoplasms of petrous apex are primarily driven by whether or not you think they have any malignant character. Chordoma and chondrosarcomas are generally treated surgically with or without radiation therapy. A small meningioma may be observed. If it's larger, it might require surgery or radiation. And the same would hold true with the trigeminal schwannoma. A small one may be observed. If it's growing or significantly symptomatic, then typically microsurgical resection, but radiosurgery is an option as well.

Dr. Jason Barnes:

And when we talk about these interventions, specifically surgery, can you tell us about the surgical approaches to the petrous apex?

Dr. Matthew Carlson:

Yeah. This is a great topic. It's something that's commonly asked on on boards and it just goes back to the idea that the petrous apex is an area that's somewhat difficult to fully access and get very good control over it. And the reason is, is it's a more medial structure and it's really surrounded by a lot of important anatomical structures that you can't really move without having a lot of morbidity. And those include, you're working around the carotid artery and you're also working around the facial nerve. And lastly, the otic capsule. And those three things really define what kind of approaches you're using.

The first question you always ask is, do you just need a biopsy or do you need to fully remove it, do you think? The second question you have to ask is, does a patient have useful hearing in that ear or not? Because then you'll either be working around or taking advantage of going through the inner ear to identify the structure or to reach the pathology. And then the additional question is, are you accessing the petrous apex itself, or do you also need access to the posterior fossa or middle fossa? Where is the majority of your tumor or the majority of your pathology?

And so I think those are the big questions that you have to ask going in when you're thinking about surgery. If you're thinking about accessing the petrous apex in a person with non serviceable hearing, then a trans lab or a trans cochlear or trans otic approach is the most direct route. And those procedures are non labyrinthine sparing. And so with the procedure, the patient would lose vestibular function and all hearing in that ear, but they can provide very good exposure to the petrous apex without any requirement for brainstem retraction.

Importantly, the difference between a trans otic and a trans cochlear, the trans otic is a situation where you suspend the facial nerve in a bony canal, meaning you leave all the bone around it and you don't mobilize it. And that's in contrast to a trans cochlear approach where you mobilize the facial nerve. The trans cochlear approach provides better exposure, but will always provide some level of at minimum transient facial nerve paralysis, but often even a mild longterm facial nerve paralysis from access.

So those are the non hearing sparing procedures. If your patient has good hearing and you want to access the lesion, then you're working around the labyrinth in the carotid artery. If it's a low anterior petrous apex lesion, a trans nasal procedure often will provide you good access. If it's a larger lesion or located more superiorly, typically a trans temporal approach will provide better access. So a middle fossa craniotomy, an extended middle fossa craniotomy, can access the anterior petrous apex quite well. You could perform a quasi triangle approach where you're drilling the bone between the petrous apex and the trigeminal nerve laterally to your petrous carotid artery, medially to your petrous ridge and posteriorly to your internal auditory canal. And that provides some exposure to the petrous apex in the posterior fossa.

You can also perform a retro labyrinthine approach, and that's good for more posterior base lesions. You can also even perform these limited procedures such as the infra cochlear approach. And that's really probably only good for a biopsy or opening a cyst, for example, or even a subarcuate tract, you could open a subarcuate tract. There's been several reports of doing that, but again, very limited access overall.

Dr. Jason Barnes:

Well, Dr. Carlson, thanks so much again for being here. We've discussed a pretty dense topic and I'll try to review it here quickly. We're talking about lesions of the petrous apex. The most common symptoms that are localized to this region are trigeminal hypoesthesias due to the proximity of the fifth cranial nerve and retro orbital eye pain or lateral rectus palsy, especially due to the sixth cranial nerve being nearby.



There are normal variants that are sometimes mistaken as pathologic, and these include effusion, asymmetric marrow, or asymmetric aeration of the bone. And when we break down lesions of the petrous apex, we can break them down into four separate categories. Cystic lesions, which comprise the majority of these lesions, infectious lesions, solid neoplasms, and other things such as aneurysms and osteo dystrophies.

When we talk about the cystic lesions of the petrous apex cholesterol granuloma is the most common. And it's important to remember that these are hyperintense on pre-contrast T1 and T2 MRI. Epidermoid is another cystic lesion and the buzzword here is that these will be bright on MRI with diffusion weighted imaging. Mucocoeles are also included here. They'll be isointense on T1, hyperintense on T2, and can have rim enhancement on T1 with contrast.

When we talk about infectious lesions of this area, the main thing to focus on is Gradenigo's syndrome, which is more historic, but this is described as a six cranial nerve palsy, retro orbital eye pain, and otorrhea. Solid neoplastic lesions include meningiomas, which are homogenous, have dural tails, and are bright on T1 with contrast. Trigeminal schwannomas, which can have dumbbell appearance and will be bright on T1 with contrast, that will be more heterogeneous than meningioma. Chondrosarcoma will not be midline because it will be closer to the foramen lacerum. And chordoma will be closer to midline, emanating more likely from the clivus.

Surgical intervention depends on the lesion and things like cholesterol granuloma do not require surgical intervention all the time, but other things like epidermoid and mucocoeles, surgical intervention should be considered. And finally, when we think about the surgical approaches to the petrous apex, if we're not trying to spare hearing, we can consider trans lab trans otic or trans cochlear approaches. There's also the possibility of trans nasal endoscopic approaches. There are trans temporal approaches, including the middle cranial fossa, craniotomy. And then for more limited exposure, you can do retro labyrinthine and infra cochlear approaches.

Dr. Carlson, that wasn't really a nutshell, but is there anything else you have to add?

Dr. Matthew Carlson:

No, I think this covers a very dense topic, as you said earlier, and hopefully we were able to weave in and out some main concepts that you can remember and also apply to different pathologies. And also, hopefully we did a good job of injecting a lot of the high yield board review topics. This is an area that's commonly tested on, particularly from the standpoint of imaging features. Thanks for having me.

Dr. Jason Barnes:

Well, it's time to bring our episode to a close, but before we do, we'll finish with some questions. As a reminder, I'll ask a question, pause so that you have time to think or press pause yourself, and then give the answers. So the first question is, define the anatomy of the petrous apex.

The petrous apex is best described as a three-dimensional triangle with the base located at the otic capsule or the superior semicircular canal. And the peak is at the clivus. The medial side of the triangle faces the posterior fossa and the superior boundary is the middle fossa.

The next question is, what is the most common lesion of the petrous apex and what are its characteristic image findings?

The most common lesion of the petrous apex is a cholesterol granuloma, and this is characteristically hyperintense on pre-contrast T1 and hyperintense on T2 sequences.

The next question is, what is a petrous apex epidermoid and what are its imaging characteristics.

An epidermoid is histologically identical to a cholesteatoma. The center of the cyst contains keratinous debris and the outside has a wall of stratified squamous epithelium. The lesion is hypointense on T1 and does not enhance with gadolinium, and its hyperintense on T2. But most importantly, the lesion restricts so it's bright on non echoplanar diffusion weighted imaging.

For our fourth question. What is Gradenigo's triad?

Gradenigo's triad is classically described as a cranial nerve sixth palsy retro orbital pain and otorrhea. This is typically associated with petrous apicitis, a condition that was more common in the pre-antibiotic era.

That'll do it for today. Thanks so much for joining us and we'll see you next time.