Alyssa Smith:

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Dr. Garret Choby:

Hello there, and welcome to another episode of ENT In a Nutshell. I'm your host, Garret Choby. And today we have special guest, Eric Wang to talk about skull based reconstruction. Dr. Wang is an associate professor and vice chair of clinical affairs at the University of Pittsburgh Medical Center. With co-appointments in the departments of neurosurgery and ophthalmology. And on a personal note, he's one of the main inspirations and reasons why I got into the field. And has been a great mentor and friend through the years. So Dr. Wang, thanks so much for joining us today.

Dr. Eric Wang:

Thanks so much for having me Garret. I really appreciate the opportunity to be here.

Dr. Garret Choby:

Absolutely. So our topic today is skull base reconstruction. And primarily we'll be discussing this in a sense of tumor resection or other endonasal cases. There's a separate episode out there on spontaneous CSF leak. So we won't be discussing that too much today. Dr. Wang as we get started, I wonder if you might just give us information on the background of endoscopic skull base surgery and reconstruction. And sort of where we've come over the past decade or so.

Dr. Eric Wang:

Yeah, I mean, it's actually a really interesting evolution. And you can see that skull base reconstruction was really unfortunately one of the hindrances to the broad scale adoption of endoscopic endonasal skull base surgery initially. When this first began whether you believe it in the mid '80s or early '90s. Using the nasal cavity to get to cellular tumors like pituitary tumors was actually pretty well accepted in many ways. Because we had used the nasal cavity to get there using a microscopic technique before. But as it started to expand beyond that and they started to expand the boundaries beyond the cellular and the pituitary.

That's when actually we started to see some of the complications associated with the new technique. And the primary complication was the reconstructive techniques that they use for pituitary tumors. Were really different from when you expanded that approach to the area immediately superior to that. Like in the planum or the tuberculum. And it's an interesting area because the real estate is very tight there. But the reconstruction can be challenging. At least it was initially. And so when we just depended upon free tissues, where we take a tissue from somewhere else in the body like abdominal fat. And try to plug that site. The historic CSF leak rates were unfortunately very high.

25, 30, even up to 40% was commonly seen. And obviously that degree of postoperative complication wasn't very well accepted when there were other approaches. So what ended up happening was in 2006, a very illustrious group actually here at the UPMC before either Dr. Choby and I were here. Began to start with an anatomical study using the posterior septal branch of the sphenopalatine artery to provide blood supply to the nasal septum. And they essentially inverted this nasal septal flap and placed it up against the sella. Now providing a piece of tissue and flap that was arterially supplied. And essentially could live on its own.

And this was really a huge turning point in reconstruction for endoscopic skull base surgery. Because now we had a valuable and relatively easy to harvest reconstructive technique. Which dramatically reduced the CSF leak rates to where they currently live now. Which is usually broadly accepted to be less than 10%. And in most centers somewhere between five and 7%. And so that paradigm was really a significant invented skull base surgery. And I think it highlights one of the key things about skull base surgery. Which is that this is really a dynamic team surgery. So, there are many surgeries that we do that you use multiple teams in otolaryngology. For instance, head and neck reconstruction for large ablative cases.

A lot of times there's an ablative surgical team and a reconstructive team. And skull base surgery is similar in that it is required or is frequently done with a two team approach. And it was really through this combination of skull base surgery entering into the intercranial space. The neurosurgical space traditionally and otolaryngology having a huge knowledge of both the nasal cavity. Its vascularization and the potential for these reconstructive techniques that really kind of have brought us to our current status. And it's the blending of these two specialties that I think has made this field so dynamic and so exciting for so many of us. I think, including both Dr. Choby and myself.

Dr. Garret Choby:

Yeah. I agree 100%. And that's a really nice summary of sort of where we've come from and where we are now. And I certainly agree with the importance of the sort of co-pilot or co-surgeon technique with many of these cases. So Eric, maybe you could tell us a little bit about... In your experience, how does this merger occur? So there's both the otolaryngology team and the neurosurgical team. There's a lot of things that background as well that must be considered. Things like departmental support or coordination of operating rooms and those kinds of things. So maybe you could speak to a few of those items as it relates to endoscopic skull base surgery and reconstruction.

Dr. Eric Wang:

Yeah. So, I mean, that's a really great question. And one that is in some ways very nuanced. I think different teams found different pathways to it. But it starts with having individuals who really care about it. Because it takes a commitment both from the otolaryngology side, as well as the neurosurgical side to work together. And find a way to make it happen. So I think you need to first start with that baseline desire to work together. And both sides can see the benefit of having the expertise of the other side. I've learned so much neuroanatomy from my neurosurgical partners over the years. And in the same way, I hope that I provided some knowledge about the nasal function and endoscopy. And it's that mutual appreciation of the other teams skillset and knowledge I think that paves the way for that.

But once you get beyond that base requirement, one of the greatest challenges is keeping a team together. And finding a way to make the logistics of it work as you are alluding to. It very much helps if you have institutional support. If the institution feels that this is an important Avenue and approach to have available for patients. If they believe in the benefits of it, then that really helps to line up the logistics of providing operating room time. So both sides can be there. We really believe in trying to line up the clinical time as well. Because patient convenience is a big factor in this. Patients want to be able to see both surgeons without having to make multiple trips. And so we try to line up our clinics in addition to the other services that are involved. Including ophthalmology, endocrine surgery, endocrine medicine. Especially if you happen to have a neuroendocrinologist.

And so lining up all those various parts of the team takes a lot of diligence and coordination. But once that happens I think you can get me again to consider this idea of a center of excellence. Where what you're able to do is provide a multidisciplinary approach to any particular tumor. And that allows

you to now have the opportunity to provide the patient the very best options. Whether it be surgical or nonsurgical. And I think that's where patients start to begin to get a lot of value out of it. And then it's also very rewarding for you as a physician and provider that you're able to give the patient the very best opportunity. So I think that there are a lot of nuances as we often say learning to dance. Getting everyone to coordinate together. But I think that once those learning pains are sort of over the end product is really a very valuable thing. For both the patient and then for us as the healthcare team.

Dr. Garret Choby:

Yeah. I couldn't agree with you more. I think those are all really important aspects to think about as you think about starting a team. And taking on these sort of cases. Now, as we get a little bit more nuanced into the skull based reconstruction realm, I wonder Dr. Wang if you could talk to us a bit about what sort of patients are we talking about that may need skull based reconstruction? So what kind of pathologies, tumors, locations are we thinking about that may be applicable to these situations?

Dr. Eric Wang:

That's a great question Garret. So starting out, I think that we all start out with pituitary tumors. Predominantly that's pituitary macroadenomas when we begin. And then functional pituitary tumors. And the reason we start there is because number one has the highest prevalence. It's probably the only tumor that has sort of widespread prevalence. Such that you could actually identify it individually as a pathology that stands alone. And so there's a couple advantages to starting with pituitary tumors. Number one, it's very easily accessed through the sphenoid sinus. So it's kind of very much in our wheelhouse. Number two, the tumors in general are typically pretty soft. And so they're easy for the two teams to work with. And number three is, they tend to be kind of centrally located.

Such that all of our skillsets are really lined up. The tumor access tends to be in the right plane. The reconstruction tends to be in the right plane. So it's the real ideal tumor. And the outcomes generally speaking are very good. But then once you start to expand beyond pituitary tumors, now we get to a variety of more rare pathology. So looking at me at least superior to that. The two most common things that we deal with in the next stage are craniopharyngiomas and tuberculin meningiomas. As you know meningiomas can occur anywhere. There's dura and dural lining, but tuberculum ones are interesting. And that they tend to present somewhat early with visual decreases. So again like bitemporal hemianopsia.

And then craniopharyngiomas are an ideal corridor. Because the transcranial corridors that are typically used, you have to work around the optic nerves. While in this particular setting, we work underneath and behind the optic apparatus. So those are the next two pathologies that most people sort of move on to. And then as we go more anterior than that, we get into the tumors that we as otolaryngologists care about a lot. Then we start to look at things like meningoceles. Like a meningoceles for children. Which kind of falls into that spontaneous CSF leak talk that we had previously discussed. But additionally we can also think about things like sinonasal cancers. And it's amazing how different we're able to now consider and treat these tumors.

We started off with benign tumors like inverted papilloma. And now in many centers, including I believe Dr. Choby's and mine. We do quite a bit of malignancies through this endonasal corridor. And the benefits towards facial aesthetics, function, hospitalization times. I think there's a multitude of benefits to it. And we're still trying to prove others. But the early analysis of these rare tumors show that the margin negative resections are actually very parallel. And so it's a really an area of intense investigation I think among many centers. But also is very much in our otolaryngology wheelhouse. And then as we look interoinferiorly, we start looking at clival tumors like chordoma's and chondrosarcomas.

And although there are many different and alternative ways to approach meningioma, perhaps clival chordoma is actually the new workhorse case.

Because that's a tumor that grows in the bone of the clivus. Which sits kind of behind the nasal pharynx and makes up most of the lower sphenoid or most of the posterior sphenoid. And it really is a bony tumor and we have such beautiful and direct access to it. Through an endoscopic skull based approach. And I think that the alternatives like far laterals they exist. But they kind of pale in comparison to the direct access that we can get through and endonasal approach. So this is a really exciting time as the indications for this. Maybe we aren't expanding so much anymore, but our ability to be nuanced in our approach for this is really at an all time high.

We can really make very clean and delineated decisions based upon tumor location. And their relationship with key neurovascular structures. And all of these tumors are now sort of in play for the endoscopic, endonasal approach. With the one caveat of being that we do have to be able to successfully reconstruct them. Because we don't want to go back to that pre 2006 period. Where CSF leak or the reconstructive aspects of it become the greatest hindrance for the successful surgical approach. We really want reconstruction to continue to walk parallel with both the tumor resection and a surgical approach.

Dr. Garret Choby:

Yeah. Perfect. That's a great summary of sort of the areas and the tumors that we're dealing with. And I think it also highlights the fact as something that you once taught me. That things like clival chordoma's, the endoscopic endonasal approach is not just the most minimally invasive option. But in some cases like that, also the best maximal exposure you get to those tumor types. So a really good summary there. Now, as we transition from the tumors and locations, let's talk more about reconstruction. So as you think about a periocular case you're considering doing. And you sort of know what the tumor is in the anatomy and surrounding areas. Talk to me about what things you think about as far as patient factors go to how you may think about reconstructing that defect. In other words, things like where the defect is? Or perhaps what the patient's personal characteristics or demographics are? That may influence you in a choice of reconstruction.

Dr. Eric Wang:

Sure. Dr. Choby brings up probably the most intellectual aspects of preop decision making here. And this is really where we have to understand both the anatomy as well as the idea of the bony defect and the dural defect. And sometimes we think of them as synonymous, but actually they're slightly different. The tumor types, some of them are purely intercranial tumors like meningioma. While other things like sinonasal malignancy's, they cross both boundaries. And so what we're trying to understand when we think about defect size is first the bony defect. And then subsequently the dural defect. And this is oftentimes not only limited by our surgical approach, but oftentimes is more dictated by the adjacent anatomical structures. For instance, in a clival defect it's the paraclival carotid artery's adjacent to the clivus, which are really our limitations. Towards getting further access.

And the second thing we want to consider is that sometimes the bony exposure is going to be a little different than the dural exposure. So sometimes the dural defect is somewhat smaller than the bony defect. And that can actually help us with our reconstruction. Because we're able to sometimes dissect a plane between the dura and the bone. And actually able to use that as a buttress for reconstruction. So when we talk about defect size, we want to differentiate between both the bony side, as well as the dural side. So some areas we know have a very high flow of CSF. Unfortunately this is not something that we've scientifically measured. It's more based upon observation and our

understanding of CSF flow dynamics. But essentially when you enter into an arachnoid space or a cistern, then you're more likely to have a high flow CSF leak.

So the classic examples of this are they suprasellar cistern. That's the area where the optic apparatuses that tends to be a high flow CSF leak area. Additionally, posteriorly in the posterior fossa, the prepontine cistern. Or the area that sits right behind the climates is also another high flow area. And maybe that's in contrast to the anterior cranial fossa where the frontal lobes sometimes give us a little bit more of a low flow leak. Because the frontal lobes can kind of descend into the space. And that's also in comparison to low-flow leaks predominantly in the sella. So those are the tumor based characteristics. And once you start getting beyond the tumor, then you start thinking about your reconstructive technique. So if you're going to think about using a vascularized reconstruction, which most people like to use.

When you either have a high flow leak or you're truly into the intercranial space. Now you started thinking about the dimensions of your nasal septal flap. And how that relates to the defect size you're creating. So the classic example is the suprasellar area. So the average defect there is probably about one and a half to two centimeters even with a pretty broad defect. And the reason is that your optic nerve sort of limit how far laterally you can go. And the pituitary is immediately underneath you, so you can't usually sacrifice that. So the defect sizes tend to be well within the size for which the nasal septal flap broadly covers over this. In contrast, when you go to the intracranial fossa, sometimes you don't even have the septum to work with. If it's involved with cancer. But even if you do, the breadth and width is usually more like a four by three centimeter defect.

And that's really kind of at the edges of what the nasal septal flap can cover. That starts getting you thinking about what you might need to do to augment that vascularized reconstruction. And then the last thing that kind of remains controversial is how much does the role of BMI or body mass index play into the reconstruction? So there are definitely many reports for which increased body habitus or increased BMI are associated with a higher rates of CSF leak. And that's believed because the increase in the body mass index subsequently results in an increase in intercranial pressures. As you can imagine, since we can't suture any of these reconstructive techniques. Which is probably one of the greatest limitations of the endoscopic endonasal skull base surgery. If you have an increased pressure gradient from the intercranial side pushing against your reconstruction. That could theoretically worsen the function of your grafts and your flaps and displace them.

And so that's kind of the driving principle of that. And so I have myself published papers that have shown BMI having some effect. At least in a univariate analysis. And certainly the Iowa and the Mayo group have actually published I believe. Some on pituitaries and so there's really some evidence that supports that, but it's certainly not the only answer. But at least it plays a minor role in your thinking about what sort of reconstruction. If you have a patient where you think that the intercranial pressures are very high, it may push you towards using a more robust reconstruction if you're sort of on the fence. And that can also be with things that are like third ventricular tumors and whatnot. Which also cause hydrocephalus or any sort of increased pressure phenomenon.

So I think that those are the key factors in my mind. The other factors that people sometimes cite, which are not as clearly supported in the literature. Are things like preoperative radiation. Previous endonasal surgery. Previous skull based surgery, they may all factor in. And anecdotally a lot of times as surgeons we sort of believe them to factor in. But when we look at them in a more systematic review manner, we still don't have enough evidence to strongly state one way or the other yet. Do you have any differing opinions on that Dr. Choby? Are there any other things that you added to that algorithm that I don't?

Dr. Garret Choby:

No. I think those are all a great summary. I will say that I also give some consideration to body habitus. I think that we all operate on many folks who have a very high BMI and it just seems anecdotally at least. And at least some preliminary evidence that they do have an increased risk of leak postoperatively. So I may lean more towards putting a vascularized flap in those folks. Even if it's a sellar defect. More so than something like a free graft if I think they have an elevated discretional pressure as a result of their body habitus. But it's a really good summary. And I thought the next area we could explore a little bit is when we think about the actual reconstruction. From sort of a step wise approach or a ladder if you will.

I think it'd be beneficial to our listeners to talk a little bit about sort of an inlay and onlay concept. And what layers you're approaching. And then in particular how you think about inlays. In other words, when you may use them. And if so, what materials you may consider for an inlay when you tend to utilize them?

Dr. Eric Wang:

Sure. So sometimes it's actually a confusing concept. This inlay, onlay. And the truth is some people try to blend them together. Or actually they try to put them together so that they have a combination inlay onlay graft at the same time. Even sometimes by suturing two things together so that they could create that sort of... They call it a button approach. But essentially when we think about inlay, we're sort of thinking about something that sits in the intercranial space. And that is supported by the surrounding dura. Such that there's a nice overlap around each of the dural edges, so that it's covering over the entirety of the defect from an intercranial side. And then onlay graft actually a little bit counter-intuitively because we're kind of coming from below. Actually sits over or covers over the bony defect from the endonasal side.

So again, ideally this would have a significant overlap around the periphery of this. And sometimes the complex anatomy in the skull base doesn't really allow that to be particularly smooth. It's certainly not a flat space. It's a three dimensional space with many contours. But the idea of an overlay is that it sits in the nasal cavity. And it can surround the periphery of the dura. Now sometimes that same onlay can kind of be placed in a plane between the dura and the bone itself. So epidural plane as you all recall, kind of lies between the dura and the bone. And you can actually dissect that plane just like you would dissect periosteum off of any other bony surface. And that can provide basically a small pocket for which you can tuck that on lay graft around.

And I really like that technique when I do anterior cranial fossa reconstruction. Because the orbits usually give me some area to tuck around. And kind of sling it like a hammock for some of the reconstructive onlay grafts. And so most of our flaps or essentially all of our flaps we use in a onlay manner. At least when we talk about endoscopic skull based reconstruction. So don't get too caught up where the flap slide. The flaps almost always have to sit in onlay position. And so those are kind of the basics of the nomenclature associated with reconstruction. Inlay, onlay and people use varying degrees of both. I will tell you in general, I tend to be one of those proponents of always using an inlay material. I don't use something that's usually water tight. I usually use a collagen like matrix.

And there are a lot of different proprietary types of them from different sources. But these are not harvested from the patient. These are almost always manufactured or processed in another way. And I like that to sort of reapproximate the arachnoid layer. I believe that if I have to go back for a revision, that this layer kind of prevents some of the more sturdy, unrelated layers from scarring. To the brain or other critical neurovascular structures. Because certainly that's kind of our goal here. Is we're trying to create a very well-defined scar. Which eventually becomes our water tight seal. In contrast,

other people believe in putting things like fascia in a inlay graft. And I do think that actually does help with the reconstruction. It may make it actually more robust.

But the downside may be that if you do need to go back and do a revision if you have a tumor recurrence, then it may be a little bit of a challenge. To separate that from things like your optic nerves, your hypophyseal arteries, your pituitary stock. So I tend to use a collagen layer for my inlay material. Do you do something different Dr. Choby?

Dr. Garret Choby:

Great question. We tend to do something very similar. We use a lot of collagen matrix as an inlay. We will use a fascia lata. Especially for intercranial base defects. Or in someone who has a large sinus or malignancy resection who may be getting radiation postoperatively. We do tend to use fascia lata in those folks. But for our smaller defects, we tend to use the collagen matrix a lot. And I think for the reasons you mentioned, it is a very nice option for many of those cases. To be quite honest with you.

Dr. Eric Wang:

Yeah. And you're actually showing a great nuance there too. Because intercranial fossa... Even though the frontal lobes are important, they're a little bit less sensitive than things like your optic nerves. Or these very fine vessels like your hypophyseal vessels. Which are really important for your pituitary function, diabetes insipidus, as well as vision. And the intercranial fossa does have some important vessels like your fronto-polar vessels. But in the relative scheme, they're a little bit less sensitive. And so you're showing I think a lot of nuance in that... That's an area that can tolerate it and your goals are also quite different.

You're probably in the setting of sinonasal cancer. Really trying to make sure you don't have a CSF leak. Because you really want to get the patient to radiation as soon as possible. Right? And so you can see that with reconstruction, you're actually always blending in a lot of different factors. Both upon anatomy, as well as what your longterm goals are. And so I think that, that really shows a lot of that nuance. Should I move on to onlay? Do you want to talk about onlay?

Dr. Garret Choby:

Yeah. Let's talk a little bit. You alluded to earlier the importance of the nasal septal flap development in around 2006. It's really helped to revolutionize things. But other options are available. So I wonder if the next area to explore would be you're talking about... With your onlays or your nasal reconstruction side. Maybe both things like free grafts and maybe some select situations. As well as the vascularized restructuring options that we have available to us.

Dr. Eric Wang:

Sure. So I actually really do like free mucosal grafts. I think that they have such little nasal morbidity and you can really tailor them to your defects. Because you're not rotating things around very much. And I think that when you choose them well, they actually have a little bit less early nasal morbidity associated with free grafts. So I like them a lot for sellar defects for which there's just a very low flow CSF leak. So I would say actually that's the majority of time where sometimes the diaphragma over the pituitary tumor has been so thinned out. That it's not so watertight anymore. And there's a weeping of CSF. I find that a free graft works beautifully in that setting. Patients heal very well whether you harvest it from the nasal floor or if you happen to resect the middle turbinate. For that particular case, the mucosa from that is not wasted.

And it just provides a little extra support there. And I think that it helps promote the healing process. It's very similar to a skin graft that we use in everywhere else and in otolaryngology. Where it does depend on embedment to live. But as we pack and support these grafts take really well. Probably because it's in an ideal wound healing environment with raw surface edges. But the downside of them is that when you try to use them in higher flow CSF leaks that sometimes... Or the data suggests that they're not as successful. So the paper that most people quote the first author is Richard Harvey. And it really is a systematic review and comparison. Which really shows that free graft repair tends to have about... A free graft, excuse me. That's the free tissue, the free mucosal grafts are about at 15% leak rate compared to vascularized reconstruction. Which drops it down 7.2, 7.5. Something like that. So it's almost a 50% reduction.

And that was really quite key in sort of separating those two. But again, the caveat to that being that with low flow leaks, the success rates may be much more equitable. And I think that, that's where we tend to like to use free mucosal grafts. And as little otolaryngologists we're really I think quite skilled and we can harvest them with minimal if any morbidity. And allow the healing to happen in a very expeditious manner. But then that leads to this whole other area where a lot of skull base surgery is going. Which is these high flow CSF leaks. And we talked about nasal septal flaps. And I think there's lots of beautiful videos on how to harvest these. And how you can extend them to increase some of the reach by harvesting some of the nasal floor.

And so I think that, that's our tried and true option. That's kind of our workhorse reconstruction for the vast majority of these things. But then there are also some other intranasal flaps. The one I tend to use as my sort of salvage situation next is a lateral nasal wall inferior turbinate flap. Is that the same algorithm that you use Dr. Choby?

Dr. Garret Choby:

Yeah. Absolutely. I think that you and I probably have pretty similar philosophies on skull based reconstruction and as well as many things in life. So that's definitely my second go to for at least cases of clival defects, sellar defects. Now of course, intercranial base reach is limited there. But certainly in those areas that's my next go to,

Dr. Eric Wang:

Yeah, me too. It is technically a much more challenging flap to raise. Because you have the concavity of the inferior turbinate to work around. And the bone there is not smooth. I mean, all of you guys have done inferior turbinate reductions in your past. Or some mucosal inferior turbinate reductions. And dissecting that plane sometimes is not entirely simple without getting any tears. But again, this is still based off of the sphenopalatine artery as it arises from the pterygopalatine fossa. And in this branch... Actually there's two large branches that come down. The larger of the two actually goes to the inferior turbinate. And the smaller of the two goes to the medial portion of the inferior turbinate. And one of my really outstanding fellows Felipe Levine did an anatomic study with case series on this. Which is hopefully going to get published in the International Forum of Allergy & Rhinology soon.

It has been accepted, but I don't know when it's going to actually get published. But it shows the anatomical differentiation and it justifies in some ways going through that extra hassle of harvesting the inferior meatus. Because of the increased blood supply to that area. And I think that there are also some very nice papers showing its vascular supply on MRI. So this is truly an arterially supplied flap. But you do have to sort of work around the inferior turbinate. The reconstructive surface itself is quite a bit smaller than the nasal septal flap. I usually end up using most of the lateral nasal wall as the

predominant reconstructive surface. With only a part of the inferior turbinate. And then the last small theoretical risk is that we do have to lift the area out of hazardous valve or the nasolacrimal duct ends.

And so theoretically there's a risk of epiphora that can occur from this. Although anecdotally, I haven't seen this with any frequency at all. But it's a theoretical risk there. And the other theoretical risk is that unfortunately, most of that inferior turbinate bone doesn't survive. And can't be remucosalized. And so that has a theoretical risk of perhaps promoting empty nose syndrome as well. So these are the things to think about.

Dr. Garret Choby:

Yeah. Good point. I do find that these patients don't tend to get those symptoms as much as some other patients we may experience. But it is certainly a theoretical risk for sure. You alluded to earlier as sort of a nice segue that in some cases such as maybe a sinus or malignancy, your intra-nasal recon options may not be there. So the septum may be involved by tumor or perhaps your inferior turbinates have a great reach there. And in those cases there are regional options. So I wonder if you could talk to us a little bit about things like para cranial flaps or temporal parietal fascial flaps. And how they may play a role in this reconstruction?

Dr. Eric Wang:

Absolutely. I mean, sinonasal cancer is really a challenge because it tends to present so late. And the tumors don't have much anatomical space to grow. They grow into things quite rapidly. And especially since a lot of the primary nasal cavity tumors like a esthesioneuroblastoma crossing over the midline may eliminate the septum very quickly from the algorithm. So some people still continue to use multiple fascial layers or even acellular allografts to do their anti intercranial fossa reconstructions. And they have a lot of success with them. But others of us have not had quite the positive experience with that. And so that prompted people to start looking, "Well, what can we do to cover the intracranial fossa with vascularized tissue?" Again, going back to that concept that vascularized reconstruction has a lower risk of failure than non-vascularized reconstruction.

And so the pericranial flap has been a tried and true vascularized reconstructive technique. For intercranial fossa, open cranial facial resections for a long time. The tissue is built off of the super trochlear and super orbital vessels. And so it has two arterial supplies from both sides that can actually be harvested. Both the right and left side. And when we did bicoronal incisions to access the intracranial fossa, it was readily available. And so as we began to shift towards using endoscopic techniques so that we wouldn't have to retract the frontal lobes, the pericranial flap is still there. And so the initial study was actually described by [Adams Onision 00:35:46] using multiple small incisions. And an endoscopic technique very similar to an endoscopic brow technique. That you might use in a facial plastic surgery to harvest this.

Some of us have kind of moved away from that. And now just make the bicoronal incision and harvest this pericranial flap. But the challenge then became how do you get it into the nasal cavity since you don't have that craniotomy to work through. And so the fairly clever technique that was sort of derived by Dr. Snyderman [inaudible 00:36:19] at the time was actually make a small nasotomy. So make a small bone in the... A small opening of the nasal bones kind of at the nasal frontal suture. And then pericranial flap can be tucked into that level. And interestingly, that level is essentially right where the intercranial fossa defect is. It sort of mostly matches up with the posterior table defect for most of these defects. And then it comes right across from that.

Now its downsides are that it could block off the frontal sinuses. And so many of us continue to use a draft three frontal sinusotomy to make a broad opening to try to prevent that. And it doesn't heal

as quickly as a mucosal line surface. Because it's really more like a vascularized fascial layer. And so it can [inaudible 00:37:05] into crust and take longer to heal. But it is a very robust vascularized reconstruction. The tissue can be quite large. You can even harvest it unilaterally or bilaterally. And you can reconstruct a very large defects actually all the way back to the optic nerves using a pericranial flap. And so this has become our go to option where we don't have intranasal vascularized reconstruction. Especially for things like sinonasal malignancy. Do you have a similar approach to that Dr. Choby?

Dr. Garret Choby:

We do. We like that option a lot especially when there's very little options left in the nose. We have also occasionally used things like a multilayer fascia lata graft in some situations. But to get a nice vascularity, the pericranial flap is really nice in that area. And I'll also echo. It's a little confusing when you first started doing it. In regards to the relationship with a flap to the external sort of a world than introducing it intranasally. But still allowing your frontal sinus to flow around it. I think that draft three is a very important part of that for sure. Any experience at all with reconstructing things more posteriorly without flaps or things towards the clivus? Or do you tend to lean towards temporoparietal fascia flap there?

Dr. Eric Wang:

We have used pericranial flaps for that. So we actually looked at our failures in clival defects. And actually found that pericranial flaps were probably the best answer for us for some of those early failures. I think that work is getting vetted right now in some of the skull base journals. But we actually found that it was pretty reliable for us. Now, it does require you to repeat the sinus work. Sometimes you can just do it down one side like one ethmoid roof and playing them. And you do have to harvest a fairly long flap. But it does seem to be a very reasonable option for that. Temporoparietal fascia is again a very robust flap. You do have to... That's based off your superficial temporal artery. So the harvesting of it requires some meticulous dissection.

I personally doppler it out first through the skin. Kind of like we do for perforators for ELTs and whatnot. And kind of actually trace out the whole vessel. Because it is very superficial as you know. We can all feel our superficial temporal right in front of our oracle. And so it is superficial, so the harvest of it has to be done with some care. But learning how to harvest it I think is not too difficult for most of us as otolaryngologist. But the inset into the nasal cavity can be quite tricky. The couple of caveats I've learned over the years is I now make a lateral canthotomy like sometimes we do for trauma. Or for tarsorrhaphy or for doing a tarsal sling.

And that gives me a corridor right over the temporalis muscle. And it gives me a closer set of hands. And then we still have to sort of choke hard into the side of the maxillary sinus or right where the inferotemporal fossa becomes the pterygopalatine fossa. And so it's that trocaring it in of the flap. Which is always to me very challenging. And I'll be honest with you. Sometimes I worry about how my flaps are going to hold up with all that manipulation into the cavity, but it is... Because it's laterally based, it does have a good lower reach. And so still a long way you have to sort of pass it along the posterior maxillary wall or the pterygopalatine fossa. Then immediately above the eustachian tube and then into the clival defect.

So there's a lot of twists and turns to get it into that space. But that being said, it is a good reconstructive option. It does take some work and takes quite a bit of meticulous dissection and passage of the flap into the space. But it is a good regional option perhaps not any of our favorites to use. But it's certainly there for us. Do you have any difference in your experience with that?

Dr. Garret Choby:

I agree 100%. Admittedly this is... I don't tend to raise this flag very often. If I have something that's down low towards the clivus, I really do my very best to raise some sort of lateral nasal wall, inferior turbinate, or extended flap in that way. And get it to rotate over. But this does play a role in those cases. I will echo. The challenge I think is primarily getting it from outside through the maxillary sinus PPF area. Then swing it around back towards the clivus. There's a lot of twists and turns there and you worry that, that artery takes a lot of kinks along the way. But as you mentioned, it's a robust flap and certainly it plays a role in some of these scenarios.

And then lastly, I think just briefly, there are some situations where either nothing else is available or nothing else has worked. And you may end up turning towards a free flap in some of those situations. In my practice, this is pretty rare scenarios. I think that you have some experience in this. And presented a nice case I believe last year as well. So maybe you could just briefly talk about when you might think about a free flap.

Dr. Eric Wang:

Yeah. So this is kind of very similar to the reconstructive ladder we think about in our other areas of otolaryngology. And so free flap is kind of the end to answer. The challenge is the inset. The inset and then the passage of the vessel. And so we have largely... Again, thankfully don't have a gigantic experience in this. But it's usually in situations where all of our reconstructive options are burned. And for us it's essentially always been in the posterior fossa. In the clivus. This is really where we had to use this. And we've experimented with both ALT, vastus, as well as radial forum. And largely I've kind of come to the point where I really like the radio forum the best. I think the tissue is more pliable and easy to work with as far as the inset goes.

But basically the vascular pedicle hooks up to the facial arteries. And we create that space by performing a maxillotomy. So using a traditional Caldwell-Luc approach, like a gingival buccal sulcus incision. I tend to make a hole in the anterior maxilla and the canine fossa. And then laterally I personally like to preserve the buttress. The zygomatic maxillary buttress and then make a lateral maxillotomy. And then immediately I make an endoscopic medial maxillectomy so there's basically... The only thing left in the maxilla is buttresses. By the time we're done it's a nasal maxillary buttress and a zygomatic maxillary buttress. But that gives us access to the masseteric space and the premasseteric space for which you can create a tunnel. A soft tissue tunnel down to the facial vessels.

And then the vessels then are passed over the posterior maxillary wall. Very similar to what we were talking about with the temporoparietal fascial flap. And then the free flap can then be inset predominantly for me into the clival defect. And I will admit to you, I put on a headlight and I often take the distal end I sew it kind of using an adenoidectomy approach. Where I retract the soft palate and actually put in sutures on the most inferior end into the basil pharyngeal fascia. Because I feel like that that kind of gives us that last layer of support there. And I find that most of the leaks happen on the most inferior aspect of it. And then we can able to pack the rest of it in a traditional skull base fashion. I guess that kind of segues us into packing material. But I think that I tend to like to use gel foam predominantly in the central portion of the cavity.

There's a lot of controversy about things like oxidized cellulose on the periphery. And how much epithelial damage it may create. Although I still tend to use that sort of a scotch tape around the flap. And then pack it with a gel foam and then I think that... And then the final layer packing I think is a little bit of still something we're sort of understanding and exploring. We haven't really done this in a very scientific way at all. Most of this is anecdotal, but increasingly people are moving away from non-absorbable packing to absorbable packing. I think there's a lot of patient comfort associated with it. But I

will admit in things like clival defects. Especially if I'm using radio forearm free flaps. I have a tendency to put in non-absorbable sponges in that setting. Just to really try to get as much pressure up against it as possible.

Dr. Garret Choby:

Yeah. I do the same. For most of my routine things I tend to use absorbable packing. But for those situations where perhaps it's a sinus of latency with a large anterior cranial base defect or a clival defect, I tend to go towards a non-absorbable sponges in those situations. And I tend actually to use a glove mirror cell in most of the situations.

Dr. Eric Wang:

Yeah. That's my favorite too. I feel like it comes out quite well. It's a little bit less uncomfortable. What do you do for your suprasellar defects at this point? For things like tuberculum meningiomas and cranial. I think that's kind of where I'm sort of in between.

Dr. Garret Choby:

I agree with you. That's a tough area because it can be quite a high flow leak. When we have a nice inlay with some sort of collagen matrix, then I have a nice flap to put over that. I still will use residual pack in those situations. So I tend to use just similar things. Oxide cellulose from the edges, and then I'll use gel foam centrally. I do use usually some sort of tissue glue. It's probably more belt and suspenders than anything. I don't have too much confidence in that. And then I will use some sort of non-absorbable packing from there. And it seems to work pretty well most of the situations to date. But I think a non-absorbable option is not wrong in that situation for sure.

Dr. Eric Wang:

Yeah. I think that's where I am kind of at my point too. I like the reabsorbable. I think the patients like the non... I swear the patients like the re-absorbable packing. It's certainly more comfortable. And that's kind of where I am in my learning curve with that too. Is I'm using it in those suprasellar defects when I feel pretty confident in the rest of the reconstruction. And then kind of slowly expanding. But for clival defects and the big sinonasal malignancies. Where my big goal is just to get them to radiation soon. I tend to still be pretty conservative, but I'm sort of growing and learning through that as well.

Dr. Garret Choby:

Yeah. I agree it is pain for the patient. For instance if you have a big defect and the septum's gone. And you've got maybe four or five of those mirror cells in there. It certainly uncomfortable. But I think the importance of getting the radiation and getting healed up is probably worth the discomfort. Now I wouldn't ask you briefly... Through the years lumbar drains have been utilized and maybe fell out of favor more so recently. You have done some work in this regard in the entire... UPMC group has done a lot of work in this regard. Maybe just talk to us briefly about your experience with lumbar drains. And when you may consider them and when they may have benefit.

Dr. Eric Wang:

Sure. So I think what you're referring to Dr. Choby is a randomized controlled trial on lumbar drainage. And randomized controlled trials... I mean they're really wonderful to have as a data point. They're hard to accomplish. But basically what we did is we did randomize these patients to either three days of lumbar drainage after surgery or not. And we are blinded to whether we are going to drain them till

after the surgery was completed. So we put our lumbar drains in at the very end when we did so. And we found that clear insignificant benefit of lumbar drainage. But there is a couple caveats to that. Firstly, low flow sellar defects weren't even considered in this study. We didn't even consider them as part of it. So we don't use it as a routine pituitary defect or spontaneous CSF leaks.

Those are separate. But when we're starting to talk about high flow large dural defect. Our inclusion criteria was one by one centimeter dural defect. And so in the super sellar region, actually we didn't find a benefit to lumbar drainage. And it's just as you were talking about. The size of the nasal septal flap, the reconstruction in comparison to the size of the bony defect. The nasal septal flat provides wonderful and broad coverage over all the edges. And so in that particular situation actually lumbar drainage wasn't beneficial. So for super sellar defects we don't use them. And again, I think this is a product of both tumor location and size of the defect. In comparison to the size of our predominant reconstructive material.

In contrast though, the posterior fossa where the nasal septal flap is actually barely large enough to cover. Even when you extend it to its maximum dimensions, we actually found a clear benefit to lumbar drainage. It was pretty dramatic actually. This was probably the driving force where we had to stop our study early at an interim data safety analysis. Because of the clear difference between it. But it was almost a 30% CSF leak rate from the posterior fossa without lumbar drainage. And it dropped to less than 10% with. So that was a pretty drastic difference and it's really changed our practice philosophy.

Dr. Garret Choby:

Absolutely. And I would also just say in general kudos for doing the randomized controlled trial. In a world where we do very little of those for this type of work. So I think that was a really important landmark publication.

Dr. Eric Wang:

I really appreciate that. And I think it was a lot of people being diligent. I know you actually contributed to that when you were here. Everyone had to chip in. It certainly wasn't an easy thing to accomplish. It required actually the work of many people who aren't actually listed on the final publication. But so the last area is the intercranial fossa. And this is again where some nuance occurs. We did find a benefit to the intercranial fossa of lumbar drainage. But the caveat to that is that it's very small percentage of esthesiodic that were in it. So it was 20, 22, 23 olfactory groove meningiomas and only eight esthesiodic. And interestingly the esthesiodic, there was no leaks in any of them. Whether we drained or didn't drain. So I think this is an area that at some point it may be worth it for us as a larger group of skull-based surgeons to go back. And re-explore because I think that there's some caveat there that might make it interesting for us to understand that better.

Dr. Garret Choby:

Yeah. That is a great point for sure. And I think it also speaks to your earlier discussion of location of defect and how that may affect flow of things. Like the posterior cranial fossa. You guys compared to other areas. That makes a lot of sense. And I know that we're getting ready to turn the corner here on time. I just wanted to briefly talk a little bit about postoperative care for many of these patients. And I realize that this is a fairly heterogeneous patient group. So it's difficult to answer some of these questions with a blanket answer. But as far as postoperative care goes, how do you think about antibiotics for these sort of patients?

Dr. Eric Wang:

When we use non-absorbable packing, I tend to use anti-staph antibiotics for the duration of that packing. I know that the risk of toxic shock syndrome is small and antibiotics aren't necessarily evidence-based towards preventing it. But I think many of us still practice in that way. When we moved to reabsorbable packing, I think that it was a shift for us in thinking about antibiotics. And we're actually trying to study that now again. But I tend to still use about five days of anti-staph antibiotics. How about you?

Dr. Garret Choby:

I do a very similar practice. If it's someone who has a small sellar defect and we haven't put a flap up, I won't in those cases. But if I put a flap in somebody where it's a larger defect than I do the same thing. I do five to seven days of an anti-staph antibiotic. I think it helps with crusting to be honest. And then maybe has some other preventative effects as far as infections go. And then what about things like... When do you have patients do saline sprays or rinses? When do you bring them back for debridement or examination? Those kinds of things.

Dr. Eric Wang:

Sure. I tend to have them use nasal saline sprays for two weeks now. And then right around the two week mark for a high flow defect, I start them on saline irrigations. For pituitary defects I'm getting a little bit more liberal. And maybe at a week I start them salient irrigations. I think there's some good flow dynamics to say that actually doesn't get that much into the sphenoid anyway. And that we're mostly just treating the nasal cavity. And if that's the case then maybe we should try to make them as comfortable as they can. And they get into the habit of starting a little bit earlier. I tend to do a very mild debridement on the first time. I usually see them at week one just to make sure everything's okay. And I'm trying to create for them a nasal cavity. Help them breathe comfortably out of their nose.

And then I attempted and see them back around four to six weeks. And there I'm actually pretty aggressive with removing a lot of the gel foam at that point. I think it just hasn't made much of a difference in my experience with it. Again, not well studied the area. A lack of data I would say. But I feel like most of the scar has largely happened at that time. At least in my belief. And so a little bit more aggressive debridement may help prevent more debridements in the future. But in our ICAR skull base, you could see that there's essentially no data on any of this postoperative care regiments at all. This is all anecdotal on how we do it. But that's kind of been my philosophy. I feel like it gets them out of having more debridements if I'm a little more aggressive up front.

Before it starts to really firm up and harden up. And it takes more effort to kind of get it taken care of. So I don't know. Maybe evolving as that goes along too. And maybe that just comes with more comfort in taking care of patients over the years.

Dr. Garret Choby:

Sure. Lifelong learning.

Dr. Eric Wang:

Always. Always.

Dr. Garret Choby:

And then last point I just wanted to mention in this postoperative care area. We have more and more folks who are diagnosed with sleep apnea maybe on CPAP. I think about functional pituitary patients like

ACTH-Secreting our growth hormone. And you almost assume that many of them have sleep apnea. How do you talk to them about resuming their CPAP post-operatively and managing that aspect of things?

Dr. Eric Wang:

So you and I are both very aware that this is an area where I think we should study. I think we need to get better answers in it. I know that you and others are working on it already. And I hope to benefit from your research as you continue to investigate this area. Anecdotally, what I do right now is we make their in hospital time. We make everyone very aware of their OSA status. So that means a minimization of narcotics. A minimization of anything that's going to exacerbate their OSA. And then we're pretty aggressive about our head up philosophy in these patients. Hoping to get some version of positive pressure by just having them sleep more upright. Right?

The analogy I often use for people is you never hear hardly anyone snoring on a plane. It's because they make us sit 90 degrees. So most patients aren't willing to sleep 90 degrees. But if you're able to 15, 20 degrees that gives you almost eight on their CPAP. So that gives us something. And then the really severe people then I supplement with some oxygen. I usually don't have... If it's just a cellar defect I'm usually willing to turn on their CPAP right around 10 days. But for all of the other larger skull-based effects, I usually wait a full two weeks.

Dr. Garret Choby:

Yeah. I have a fairly similar regimen. I obviously don't want to not treat their sleep apnea. But I also don't want them to get some air interacranially which could cause some bad problems. So I think it makes sense for sure. And then just as we wrap up today, I wondered if you wanted to mention anything to our listeners. Maybe anything anecdotally or personal experience that has either changed over your practice in the last few years. Or major lessons you've learned based on your experience. Just because you have such an amazing wealth of experience with complex cases. I thought might be useful to give you an opportunity to share some of those things with us.

Dr. Eric Wang:

Garret, that's always a great question. Because it makes you think back on where you were and where you've gone. And I mean, I feel very blessed to have worked with amazing human beings. Who have not only been willing to learn with me, but actually taught me a great deal. And so I think there's so many things that hopefully I've grown on. As you were saying lifelong learning. And some of them are personal like my understanding of intracranial anatomy. But if I were to say one kind of take home lesson to a broad audience, is that there's always a new avenue to explore, right? And just like we were talking about lumbar drains or CPAP or complications in general. There's so many areas that we can kind of grow in.

And I feel like that's where I've probably grown the most. Is just in that ability to recognize a deficiency in our knowledge base. And a willingness to now kind of tackle that. And I've learned that actually tackling it by yourself like we tried to do with the lumbar drain trial is actually really hard. And so I'm actually hoping that one of our futures is going to be that. We're all going to tackle them in a much more multi-institutional manner. And I'm really excited about that potential and that future. And probably the thing I would encourage us the most is if we're not so worried about who's going to take credit for it, we can actually accomplish a lot together.

Dr. Garret Choby:

Yeah. That's a great point. And I think just also working with other folks it also is more enjoyable. You get to know people better and you get to share your joint experiences and it can be a really helpful endeavor. So I agree on that one.

Dr. Eric Wang:

And for the readers it's actually more applicable. Because if Dr. Choby does it that way and Dr. Wang does that way. And there's eight or 10 of us working together. It really does suggest the broad scale applicability of it versus if one center does it. Then there may be some factors associated with that one. It's an exciting time for us. I think that the adoption of endoscopic skull base surgery in large part because the reconstructions have gotten a lot better. Have brought us to this point where we can answer and address some of these questions. And I'm really looking forward to what these next five to 10 years are going to show us.

Dr. Garret Choby:

Yeah. Absolutely. I agree. Well Dr. Wang, I want to really thank you for your time today. I'm going to briefly get into a quick summary of today's episode and a few questions for the listeners. But I think that I personally have greatly benefited from your mentorship and expertise through the years. So I really appreciate that. And it's a joy always to talk with you. And I think that you're a tremendous teacher, so I hope that everyone has learned a lot from your words of wisdom today.

Dr. Eric Wang:

Was my pleasure Dr. Choby and I really thank you again for the opportunity. And I'd be happy to do it again in the future.

Dr. Garret Choby:

All right. Appreciate it. Thank you.

Dr. Eric Wang:

Okay. Bye now.

Dr. Garret Choby:

So in summary endoscopic skull base surgery is a field that has undergone a rapid evolution over the past 15 to 20 years. The biggest jump forward was the ability to perform reconstruction well and prevent CSF leak in most cases. There are a number of options out there for reconstruction, including vascularized, reconstructive options, endo regional options. And the number of nuances must be considered in regards to these patients postoperative care. And a number of opportunities still exist out there in better understanding and defining this.

Now, as we do at the end of each episode, I'll ask the listeners a question. We'll give you a bit of time to think about it and then I'll give you an answer to it. Our first question today is to name some potential risk factors for a postoperative leak following endoscopic skull base surgery. So a number of factors exist out there. Perhaps the most prominent of them is obesity and its relationship to elevated intracranial pressure. Other factors may be possible. Things like previous radiation therapy and the defect location as well

As we think about advantages of vascularized reconstruction options, what are some advantages of them over things like free mucosal grafts? It's been shown that vascularized options have

a lower risk of CSF leak postoperatively and high flow leaks. As well as a potential improvement in postoperative radiotherapy and covering things like the carotid artery or other vascularized structures. Well, that's all we have for you today. Thanks so much for the time and we appreciate it. We look forward to seeing you next time on ENT in a Nutshell.