PROFESSOR YAMINI: Thanks very much, Sam, for inviting me to give this talk. As he mentioned, it's going to be two talks. So I'm going to go quickly, so we don't go over. I've got no conflicts of interest.

So basically pediatric vascular pathology in many ways is similar to adults, as far as we use the same diagnostic management, the same treatments, endovascular, radiation, surgical. And the etiologies are in many ways the same. It's just the epidemiology is different. In kids, there's a lot more various things, like stroke and stuff, are much more associated with congenital problems, such as sickle cell disease, congenital heart defects. And so these are the important differences in the peds.

And then the other thing to understand is peds isn't just one entity. When you think of peds, you have to think of patients that are less than one, one and a half years old, where they're really an infant, baby. Then you have kids that are between about one or two, and 10 or 11. And then you have the teenagers, who are really more like adults. So it's three kind of entities that you always have to think about.

I'm just going to go through various topics that we see in kids, perhaps a little bit more often than you see them in adults. But again, these are also present in adults. The one big area that we really see primarily in kids is Moyamoya disease, Moyamoya syndrome. Classically thought of as-- I don't have an angiogram up here, but a puff of smoke, where you have it progressive stenosis of the super clinoid carotid arteries, and the posterior circulation as well.

And what happens is you get development of collaterals that end up looking like a puff of smoke for anybody who's not in that field. And Moyamoya syndrome-- it's kind of two distributions. It's mainly in kids. But you also see it in some adults as well, progressive stenosis.

And there's no real clear natural history. In general, the severity of it is it's related to the onset of how fast the disease progresses. Patients present mostly with strokes, seen with MRI imaging. Adults might present more with hemorrhages, or occasionally present with hemorrhages more so than kids.

One of the things that we see a lot, especially down here, is the association with syndromes-- Down Syndrome, especially, and sickle cell. We see a lot of sickle cell patients with bilateral disease. And it makes it especially difficult. Because they have the reason for getting stroke from Moyamoya, and also from their sickle cell. So it's a pretty relatively common thing we see here.

Actually the sickle cell doctors at various places around the city send us these patients just routinely just to check them out.

Again the genetic and environmental factors. One of the things that can be associated with Moyamoya syndrome is receiving radiation. And that can lead to the pathology which leads to progressive stenosis of the vessels.

Treatment. You can try antiplatelet, anticoagulant therapy. And these patients are often on that anyway for their other problems, giving them strokes. But the real management would be surgical. And there are various techniques. Essentially you can divide them into direct bypass, STA-MCA. In kids, we don't really do that, right? The vessels are very small and very difficult to handle. So usually we think about an indirect technique, which is also done in the adults. But especially in the kids, I mean, they all would get indirect techniques.

And there are many descriptions. Essentially you can imagine indirectly placing some form of vascularized tissue, whether it be muscle or the adventitia of an artery or something directly onto the brain. And people talk about various techniques. But one that would be advocated would perhaps be sewing the surface-- the adventitia of the superficial temporal artery-- right onto the Pia of the brain to optimize collateral formation.

So essentially think about it as direct and indirect techniques. And perhaps the two put together.

We'll move on to cavernous malformations. Again, also seen in adults discrete, well-circumscribed lesions. Dr. White I'm sure will tell you all about these. There's nothing more that I could add. They would present as an adult with seizures, headaches, incidentally. And the treatment for this would be surgical. Observation of surgical.

There's anecdotal or perhaps more than anecdotal evidence of radiation. But in general we wouldn't really recommend radiosurgery for cavernous malformations. Perhaps new chemotherapeutics coming along. But again, that's a little ways away.

[INAUDIBLE] malformations. These are mostly thought of as congenital lesions. Clearly there are some that are de novo. Really require aggressive treatment in kids because of the long time that you have for these to hemorrhage. So the accumulative risk is high for hemorrhage. So they require pretty aggressive treatment. And again, a combination of surgical endovascular and radiosurgical techniques. I won't really talk about much more about the pathology. Dr. [INAUDIBLE] pretty much told you what an AVM is.

One kind of vascular malformation is kind of a special AVM would be a Vein of Galen malformation. And that's really several different classifications of these. This is basically a dilation of the Vein of Galen associated with some kind of congenital defect, some kind of in utero crossing of primitive arteries and veins leading to this direct shunt between the arterial and venous system.

There have been several classification systems for it, talking about differences in their feeders and their draining veins. Patients often present with hydrocephalus, seizures. They can bleed and lead to [INAUDIBLE] hemorrhage. And the other thing that is really the most dangerous thing that we see is because this can sometimes be a very high flow system. And if little ones get it, they can develop cardiac output failure. And that's really the most dangerous thing that we see.

Diagnosis sometimes can be made on ultrasound. But essentially, MRI, CT, and angiogram eventually.

And the treatment really would depend on the age and the cardiac deficit. I recently saw a patient that we've just been following for years. And the cardiac output was fine. No hydrocephalus. The patient was doing fine otherwise. And surgery was used years ago. But it really has a high risk. And essentially, probably the best way to treat it is endovascularly, whether transarterial or transvenous.

Pediatric aneurysms. There are aneurysms in kids. Slightly different distribution. Most common would be in the carotid bifurcation area. They present with [INAUDIBLE] hemorrhage. These patients may often have larger aneurysms than seen in adults. But they really are very uncommon. But we do see them.

I think the biggest thing to know about pediatric aneurysms is that the intracranial space is very tight. So the biggest thing that we see, the problem that we see, is the raised intracranial pressure. Which, in fact, in my experience-- and I've had two patients that we couldn't really operate on. We actually opened up their head. And we couldn't elevate their brain to identify the vessels.

And you just get so much intracranial hypertension that often it's difficult to operate on them. And so endovascular techniques, if possible. Again, it's difficult with the very small vessels. But endovascular techniques would be the best approach if it can be done. And then management of the intracranial hypertension.

These patients' outcome is-- I mean, of course they do poorly. But in general, they're better than adults. And so we used to say that this might be the one group of patients that might do very well with large craniectomies. I mean, we've done several bilateral temporal craniectomies to relieve the pressure and allow these patients to gradually recover.

So aneurysms are seen in kids. Slight difference in their location. And intracranial pressure is a major problem to deal with.

So those are kind of the general pediatric vascular pathologies that we see. Otherwise, very similar in many ways to adults. Just the epidemiology of them are different, as I mentioned. I just wanted to move on to talk about radiosurgery.

And really the main treatment for this is for [INAUDIBLE] malformations. As I said, cavernous malformations aren't going to be treated like this. Any other really vascular pathology in the brain isn't treated with radiation. So we're really going to talk about [INAUDIBLE] malformations.

And what the radiation you can assume it does is, it inures various layers of the blood vessel. Initially, you have endothelial injury, subsequently intimal injury. And it's not really a thrombosis that occurs, more a concentric narrowing of the blood vessels that leads to occlusion and blocks the AVM off, so there's no risk of hemorrhage.

Nobody's really done it, but people have discussed using fractionated radiotherapy for it. But there's no clear data on that. And the stereotactic approach will give you a higher dose at a single time, can be targeted. And in general, that's what's used.

Whether there are stage for larger AVM, so you can use stereotactic radiosurgery in different stages. That's also done. And essentially, radiosurgery would be probably restricted more to the deeper lesions, lesions that are in more eloquent areas, things that are really not amenable so much to surgery. Stage procedures for a larger AVMs, where you might treat one part of it, and then wait and treat another part of it, and essentially try to obliterate it like that. Again, it's much less common to be able to obliterate an AVM with multiple treatments.

Then pre-radiation embolization is used. And you see that a lot. But in general it often makes it more difficult to treat the patient with radiation after it's been embolized, mainly because of the imaging techniques. But also potentially because of the changes in hemodynamics and things following the embolization.

Various modalities. The studies have mostly all been done with gamma knife. But whether you use a linear accelerator or a gamma knife-- cyber knife, again, is a linear accelerator. They're essentially all the same. Really the important thing is what is the dose of radiation that the AVM gets? So all the studies have really been done with gamma knife. But essentially these are all the same.

The usual dose that we would try to get to is 18 or 20 gray. Now, there was actually one study in pediatrics recently, where they noted that people who got less than 16 gray had a very low obliteration rate in the teens. And so you would try to want to get to the margin, or to the 80% isodose, around 18 to 20 gray. The higher the dose, the better the chance of obliteration.

And response rates really are pretty good. I mean, most studies would quote somewhere between 70 and 90% or so. Angiogram-- you usually follow up in about three years. I get an MRI also at about to 18 months. But the MRI doesn't really give you a lot of information other than showing you edema in the region. The angiogram would be the way to go.

And this is just one example of a patient with hemorrhage AVM in deep location. And it was treated. And actually two years later this angiogram was done. This is some years ago. And the AVM was obliterated.

The risk of hemorrhage after treatment can be essentially-- imagine it as the natural history. So somewhere between 2 and 4% a year. A recent study said there was a cumulative risk of 25% in their pediatric age group. Again, the kids are the ones who you want to be more aggressive with. And they're the ones who may have a higher accumulated risk over time.

Just because it's obliterated on angiogram, doesn't mean that wtih radiosurgery it's always gone. You can still have some hemorrhaging occasionally. And the risk of the hemorrhaging is essentially the same as the natural history. And the risks in general of radiation would be any risk of radiation, which means edema, necrosis, in the location of where the AVM is, leading to various complications.

One other thing about radiation that I wanted to say is that, in general, radiation to the brain-- so not radiosurgery-- any form of radiation has a risk of developing vascular pathology. Which, this would be associated here with a kid-- this kid had a medular blastoma, received craniospinal radiation. And six, seven years later developed a cavernous malformation here.

So the radiation itself, vascular pathology is a risk factor of radiation in itself. And just going back to radiosurgery, just wanted to give you some-- this was from the UVA website, actually, Talking about a bunch of studies that were performed and the obliteration rates, somewhere between 70 and 90% or so, with fairly well-tolerated complications.

Again, the most important thing is the dose of radiation given. There is a tendency to try to want to give a little less. But you want to get at least 18 to 20 gray to get obliteration of these lesions. And that's it. Thank you very much.

[APPLAUSE]