Hi, my name is Dr. Ashok Panigrahy and today I’m going to talk about neuroimaging of pediatric brain tumors and this will be done as a 3 part series. In the first part I’m going to go over some of the basics of what you need to know when you are looking at an imaging study of a child that has a pediatric – that has a brain tumor and some of the different characteristics that we look at when we are trying to characterize the tumor and come up with a diagnosis for our referring clinicians.

On the first slide here I have listed some of the things that we need to figure out when we are looking at an imaging study on pediatric brain tumors. Age is a very important factor, so we do need to know how old the patient is. Location, where is the tumor located in the brain? Each area of the brain that has the potential to develop a tumor has a certain differential of what kind of tumors that we see in this area. And I’ll go through examples of each of these entities throughout the talk. Another big important factor is determining if the tumor is intraaxial or extraaxial, how we define intraaxial is something that’s confined to the brain parenchyma that’s within the leptomeninges of the brain, while something extraaxial would be outside of the PO matter involving the dura or the skull base or the calvarium. Another important factor in characterizing tumors is cellularity, meaning how cellular is the tumor, how many – if a tumor is more cellular it tends to be more aggressive and more malignant. And we can use certain imaging characteristics to evaluate that. We also look at enhancement, after giving contrast administration which can also give us certain characteristics about the tumor. We also look at edema or fluid, interstitial fluid that develops around the tumor and we use FLAIR imaging to be able to characterize that. And we even use CT imaging not always just MRI to also characterize tumors and I’ll cover some of these points.
So intraaxial versus extraaxial, when we are trying to define what’s intraaxial and what’s extraaxial sometimes it’s very easy and we can look at the images and clearly the tumor is inside the brain, it’s in the brain parenchyma. And when it’s outside the brain in the calvarium or in the dura it’s sometimes very easy to tell, but then we do get some tumors that are on the edge of the brain and sometimes it’s not always completely easy to tell.

And these are just some on the slide here I just have some pointers on what to look for to help you decide if something is intraaxial versus extraaxial. If it’s intraaxial it will tend to narrow the adjacent CSF spaces and displace the cortex toward the outside or periphery. If it’s extraaxial in contrast it’s going to widen the CSF spaces and tends to displace the brain deeper. A lot of lesions that arise from the dura will have something called a dura – or dural tail or an area of enhancement that goes along the dura so you know that it’s truly coming from the dura and is therefore extraaxial. This image here just gives us some examples of what we look at when we are trying to decide that something is intraaxial versus extraaxial and here you can see here is a lesion that looks like it’s within the brain parenchyma and it’s displacing the brain tissue inferiorly. This is another example of an intraaxial lesion where you can see the brain tissue displaced inferiorly.

Now in terms of once you’ve made a decision on the lesion being intraaxial versus extraaxial then you can go to locations within the brain and start thinking about the differentials. So if we decide that a lesion is intraaxial we can then look at other locations within the brain to decide is there a differential that’s associated with that area. And some of those locations include the cortex, and they include the grey-white matter junction, the deep white matter or if it’s inside the ventricle or
intraventricular. And for intraaxial lesions these are some of the differentials. Gliomas are intraaxial lesions, medulloblastoma, metastases to the brain, also nonneoplastic lesions can be intraaxial including infarcts, hematomas, EVMs and even abscesses.

In contrast if you decide that a lesion is extraaxial then you have to decide where do you think it’s coming from in the extraaxial compartments. Extraaxial locations include subarachnoid space, subdural space, epidural space, calvarium, subgaleal and scalp areas. The differential for an extraaxial lesion includes meningioma, pituitary adenoma, craniopharyngioma, schwannoma, chordoma, dermoids, hematomas can also exist outside the brain. You can also get metastases that go to the calvarium and infection can also be in the extraaxial space.

Now in terms of contrast enhancement that was one of the original items on the list, normally you have to have a breakdown of the blood brain barrier for the contrast which is injected intravenously in the child to actually get into the brain. However and so tumors they cause blood brain barrier breakdown and therefore can enhance, some tumors don’t. But one thing to consider when you are looking at an imaging study in an MRI scan that’s done after contrast there are areas of the brain that normally uptake contrast because they have a blood brain barrier that’s normally a little bit weaker or different and that’s a normal situation. So some of the things that do enhance in the brain that are normal include the dura, the choroid plexus, the pineal gland, the pituitary gland and then certain areas in the brain where you can see normal enhancement and it’s important to know what these are so that when you are looking at an imaging study you don’t incorrectly call something that’s abnormally enhancing when it’s just normal enhancement.
Now in terms of abnormal enhancement both location and morphology play a role in terms of understanding the patterns of enhancement. And when you look at enhancement you can first characterize it by location, where do I see the enhancement that’s abnormal? Is it in the superficial cortical layers? Is it in the deep white-grey region? Is it deep white matter? Periventricular? Is it leptomeningeal or is it pachymeningeal which is another term for dura? So you can characterize enhancement first by location. But then you can also look at the actual characteristics of enhancement regardless of where it’s located and some of those characteristics include homogeneous, is it very even in terms of enhancement that’s abnormal? Is it heterogeneous, is it very spotty, sort of all over the place, really very funky looking? That’s more heterogeneous. Ring enhancement is very clear, a very clear ring. Serpiginous usually means something that’s snake-like or gyriform may be going along the cortex and sometimes these can help distinguish the tumor types.

Now age is very important, it was one of the first things on that initial list that I started with. And therefore I always tell my trainees that when they are reading an imaging study and there is a concern of a tumor before they even look at that study they need to know the age of the patient. And that’s an absolute must. And why is that important? In each age group we only see certain types of tumors, so if you know that differential you won’t propose something that just doesn’t make sense. There is no – you know there is certain tumors that we see in babies we don’t see in adults, and there are certain tumors in adults we don’t see in babies. So understanding the age of the patient is extremely important.
What I’m going to do here is actually first talk about the very early time point on neonatal babies who are born and yes babies who are born can be born with brain tumors, it’s not common but it can happen. But what’s really interesting about it is that if I see a patient or know of a patient that is a baby that I’m told is born with a brain tumor before I even look at the imaging study I can play with odds and tell you 50% of what that tumor is going to be, and this table actually tells you that. If the baby is born with a lesion and it’s truly a tumor 50%, roughly 50% of the time it’s going to be a teratoma. So you can – that’s the most common congenital pediatric – neonatal brain tumor. So I hear a baby, this baby is born and there is a brain tumor I can tell them well you know it’s most likely a teratoma. Now I do need to look at the imaging study and make sure it is really a tumor and not something else, but that’s just the importance of knowing the age. You know what you are dealing with. And at birth you know the two major types are teratoma and then neuroepithelial tumors have a smaller percent and about 37%, and that includes ependymomas, medulloblastomas, glioma tumors, and then there is just other type of tumors that you can see.

Now what’s interesting if you tell me the baby is 2 months old that changes actually also the odds of what the tumor might actually be. So if the baby actually presents at 2 months, not right at birth, the percent of neuroepithelial tumors actually increases and the teratoma cases or the incidence of teratoma actually goes down. So if you have a baby presenting at 2 months of age with a brain tumor it’s more likely going to be a neuroepithelial tumor.

Now some of the non-teratomas, so I said again to reiterate, teratomas are the most common congenital tumors, now the other type of neuroepithelial tumors include medulloblastomas,
astrocytomas, choroid plexus, carcinomas and papillomas, ependymomas, and then other miscellaneous type of neuroepithelial tumors. Some other mesenchymal tumors, which is that other category include craniopharyngiomas.

This is an example of a baby that was born with a tumor, presented – was transferred to our hospital, there was hydrocephalus, and here you can clearly see there is a lesion. These are sagittal and axial and coronal post-contrast T1 weighted images, and we can see that there is a mass that’s arising from the suprasellar area. So if we just go by that table and this is a baby that’s born you should be able to tell me 50% odds this is going to be a teratoma and some of the imaging characteristics certainly look like that and that’s initially what I actually thought with this case. And when you look at the axial T2s it’s very heterogeneous, there are some cystic solid areas, dark on T2 bright on T2, and that is very characteristic for a teratoma. Now ironically I was wrong on this case, this actually turned out to be a craniopharyngioma. So that goes to tell you you can’t always be right. But in this particular case it did still look like a teratoma but it actually turned out to be a craniopharyngioma. So sometimes the imaging is not always 100% but the differential still would have been teratoma based on the imaging findings but it turned out pathologically-wise it was a craniopharyngioma.

Now this is another newborn with a tumor that’s in the posterior fossa and by location and this baby was actually 2 months old when they presented, and so going by those odds neuroepithelial tumors would be more likely, and this looks like it’s in the area of the fourth ventricle, we actually did some advance imaging and in the probably the third part of this – of these series of talks I’m going to talk specifically of how we use spectroscopy to look at metabolites and help us characterize tumors
because sometimes we are not always right just using the conventional imaging. We did spectroscopy here and from the spectroscopic characteristics which included elevated (inaudible) creatine, lipids we felt that this was a PNET tumor which it did turn out to be, which PNETs are in the sub – in the subclassification of primitive neuroectodermal tumors and they can have different types of features.

Now let’s go to 2 years of age, out of the neonatal period, up into 2 years of age and if you have a child that’s less than 2 years of age two-thirds of the time most of those tumors are actually going to be supratentorial. And what does that mean? Supratentorial means above the tentorium. The tentorium is the layer of the dura that separates the posterior fossa and cerebellum and the brain stem from the top of the brain or the cerebrum. And so two-thirds of the time those tumors in kids less than 3 years, less than 2 years of age are supratentorial. And the most common tumors that we see are PNET or primitive neuroectodermal tumors, astrocytomatas, teratomas and also papillomas.

Now when you go above 2 years of age that percentage starts to equal out a little bit more of the amount of supratentorial versus the infratentorial. So about 2 years of age it then becomes more of a 50/50 supratentorial/infratentorial split and this is why again age is important. In terms of supratentorial tumors we do see astrocytomatas, craniopharyngiomas, optic pathway tumors, pineal type lesions, choroid plexus papillomas. Infratentorial, the big lesions are cerebellar, pilocytic astrocytomatas, brain stem astrocytomatas, medulloblastoma and ependymomas.
So I covered how age is a very important factor in terms of determining your differential. The next area of characterization in pediatric brain tumors is location and I’ve listed here the major locations where we see tumors and once you’ve determined the age you can look at your imaging study and then determine location. Where do we see the tumor and then which is based on anatomy and then that can help you with differential. In the second part of my talk I’m going to go into details of the different types of tumors and the differentials that we see in children with pediatric brain tumors in each of these regions. Thank you.