Neural Science for Engineers
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Lecture - 24
Brain anatomy using MR images-II

So, in the previous session we have been discussing on interpreting structures within various sequences of the brain as examples I have shown you T 1 sequence image. Axial, coronal, sagittal, I have explained what these the names axial, coronal and sagittal mean and how to try to interpret various parts of the brain. There are lot of structures in the brain I am not trying to enumerate everything.

But the idea is that for somebody who is doing any kind of image processing on the brain should have some notional ideas of what structures are being process, so the image should not remain an image you should understand when you are doing a image processing techniques as to what structures are there and that is the idea of that. The effort also has been sequential in which I try to showcase structures on a 3D model which was the clay model and now I am trying to interpolate those entities which I described onto imaging.

You would notice that though I was very sketchy in my description of the 3D model, it is sketchier when you look at imaging with even these high end MR images. You would get only 7 Tesla higher, these are 3 Tesla images. These are images which have been, which have been acquired for teaching and they are real good images.

So, general images which are available are far lesser either in resolution quality or in some method of acquisition which you would notice when you do the actual image processing. I do give credit to the InVesalius software creators which I am doing using here because there are some features of the software which help me to showcase these structures.

So, this is a Sys image which is seen on the screen is the Sys image I had stopped at my description of identification of the central sulcus. Central sulcus is a landmark sulcus and once you understand this and understand the central sulcus, I am not saying these location shape or anything. The central sulcus divides the executing part from the

sensing part of the brain and that is a key landmark, and it is also evolutionarily well preserved. You have seen very low organisms having a very distinct central sulcus with separation of this process.

So, evolutionarily brain thought of isolating the executing part in putting the executing part in front and the sensing part behind and it has been continued like that.

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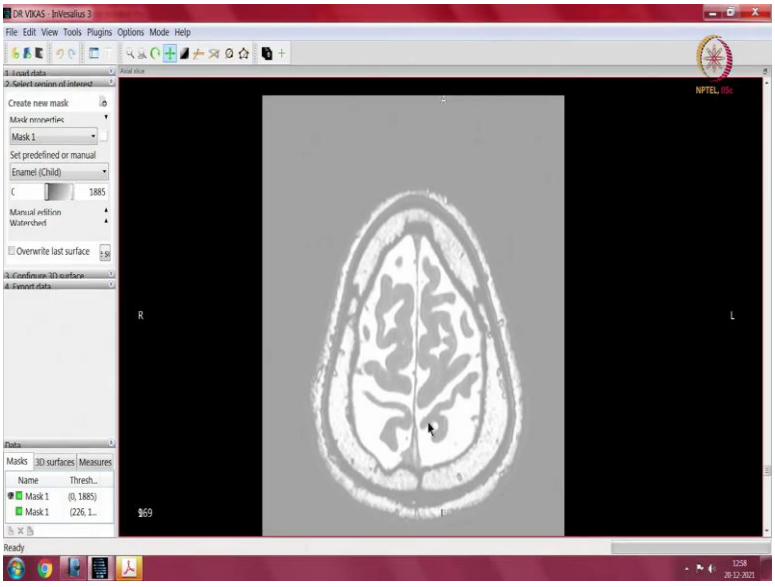

So, when we look at imaging, we find that the central sulcus starts in the midline and then goes all the way up to the periphery, that is the first landmark. We also know that the motor cortex which is anterior to it, in front of it is thicker than the sensor cortex which is in behind it and that is on another landmark.

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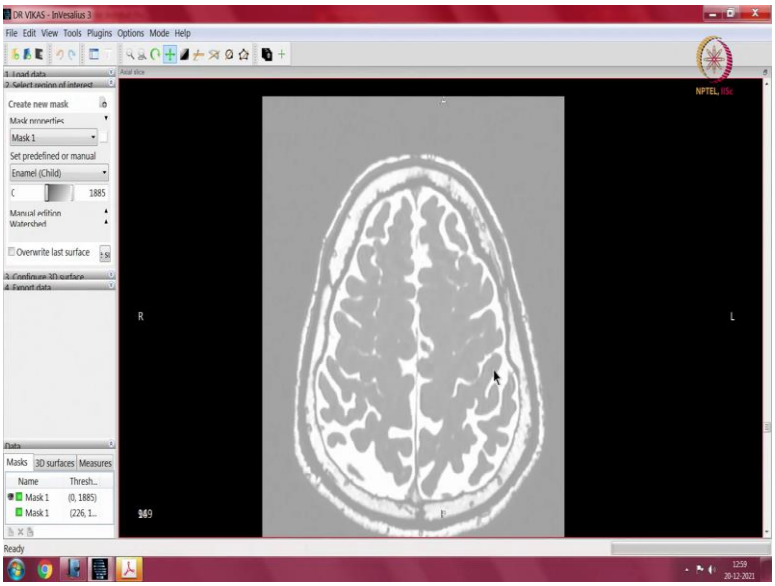

So, as I showed you have to be careful in your delineation because if you look at this section which is slightly lower down, you would find that the central sulcus which is over here is not ending up to the midline. So, it is a 3D structure. So, you should make your inferences very carefully and then identify so superiorly towards the topmost part you cannot make out anything.

So, a reasonable level is here. It sort of varies, with some experience you would understand. So, two three landmarks I have told one is starting from the center going way behind, it is a continuous sulcus you know unlike these things which are broken all over the place. Then the thickness here and here, please do note that this gyrus if it traces over here is continuing over here this gyrus which is over here is also continuing over here.

So, that is the that is another landmark that is the superior frontal gyrus. So, this whole thing is the superior frontal gyrus; please again notice how varied it is from one side to another side same person and yet it is so different on both the sides. Left side is very different from right side it is not just a small deviation from a normal, for the same person.

But it is a completely different entity you cannot make approximation. So, people in the brain atlas space can take note of it, that so many of the fundamental assumptions in brain atlases are completely way of mark. And that is why brain atlases need a lot more thought in generating, than what is currently being done. So, superior frontal gyrus

continues into the motor cortex and then that is the 7 over here you can see the 7. The central sulcus is behind that, the sensory cortex is behind that.

So, we have covered a lot of ground over there with this. Now, when I spoke about superior frontal gyrus you can notice that there is a sulcus which has come just lateral to that and that would be the middle frontal gyrus.

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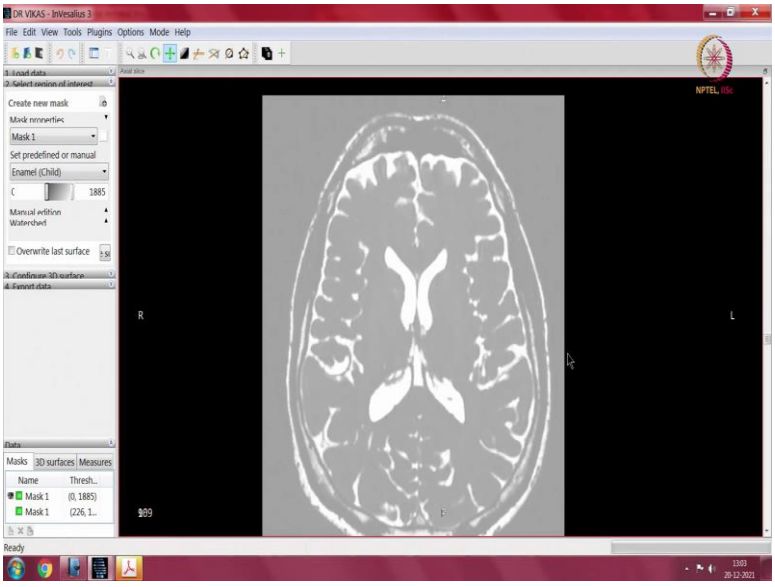

So, middle frontal gyrus still indistinct, you know you can make out that it is not very clear, that it is not as clear as the motor cortex. Again there is one sulcus which is crept up over here and that would be the inferior frontal gyrus. So, that is the inferior frontal gyrus, you just cannot make out the gyrus as such in an axial imaging and that is the difficulty of comprehending brain anatomy.

And especially intraoperative brain anatomy when you do not have the skull and you have to interpret stuff which you are seeing on table from these kinds of images which are sectional images.

So, there is a lot of scorn dripping from my mouth when I speak about this like that. The H-shaped sulcus which divides the superior parietal lobule and inferior parietal lobule are a lot more difficult to make out, it is approximately over here. So, this would be the superior parietal lobule and the inferior parietal lobule back there.

Now, going further down we cannot make out much. In fact, yeah so, do notice this structure. So, this is insula, insula is over here. Then this should be the temporal lobe, you can make out gyrus over here. So, that is the auditory cortex, the Heschl's gyrus on the superior surface of the temporal lobe. So, Heschl's gyrus there and the Heschl's gyrus approximately over here it is difficult.

See this is not a textbook from which I am drawing up an image, this is from actual person. And you should know that this is the difficulty in understanding brain anatomy and comprehending stuff which happens within the imaging space. So, posteriorly, how do I find out? Yeah, so there is this one sulcus which is coming over here and that should be the calcarine sulcus and which is where the visual cortex is located, where is the calcarine sulcus? So, calcarine sulcus should be this one. So, calcarine sulcus is fairly deep.

So, all important sulci are pretty deep, that is a way to remember things. So, that is a set of gyri and sulci which you can see. Please do note again that I am not describing all the sulci which I described on my 3D model here because there are only that much of inferences which you can get from each sectional imaging.

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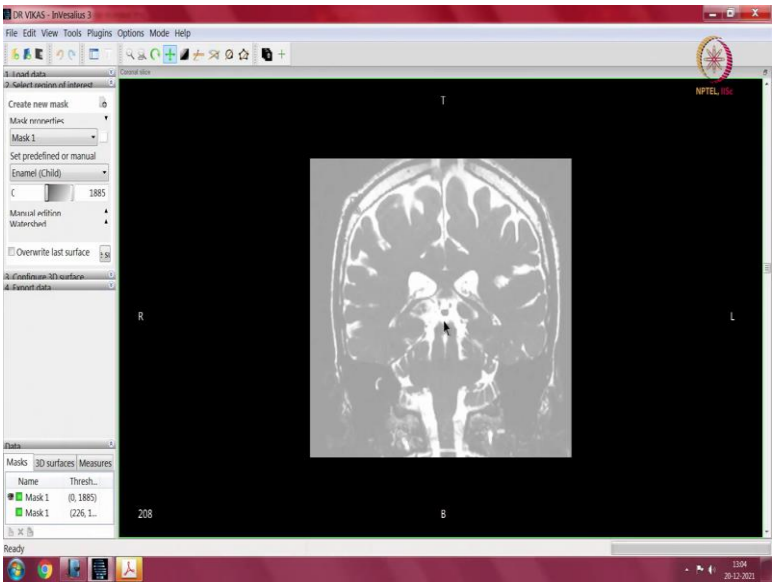

So, as clinicians and surgeons we are told that we should not interpret from a single imaging sequence, that refers to both sectional sequencing this axial, coronal and sagittal, but it also refers to various MR sequences that is CT 1, T2, flare, contrast, etcetera. So,

we now look at the coronal section and try to find out what all we can understand from this.

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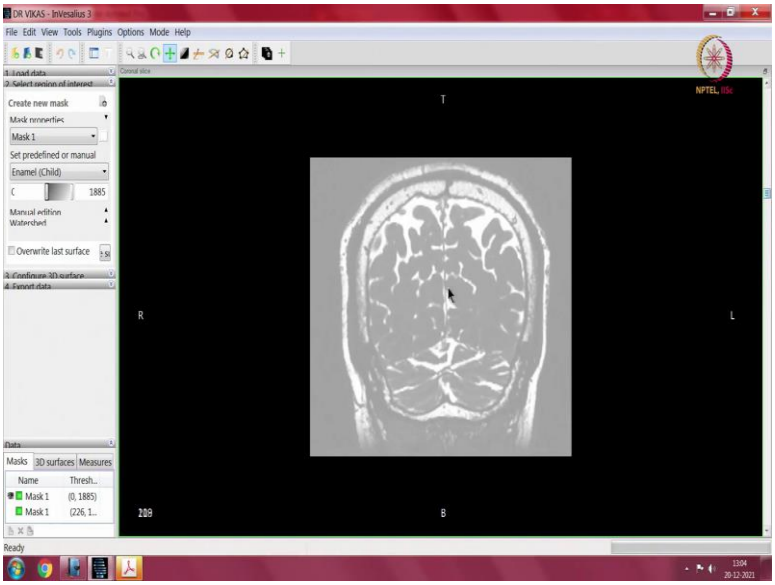

So, coronal section I told you, described how you can identify the supratentorium from the space from the infratentorium. Infratentorium is this part where the cerebellum is seen and then you can see the sharp line over here, the sharp line is the tentorium, a sharp line over here which is the falx. So, the falx separates the two sides of the cerebrum the tentorium separates the cerebrum from the cerebellar hemisphere on the same side. So, that is how it is.

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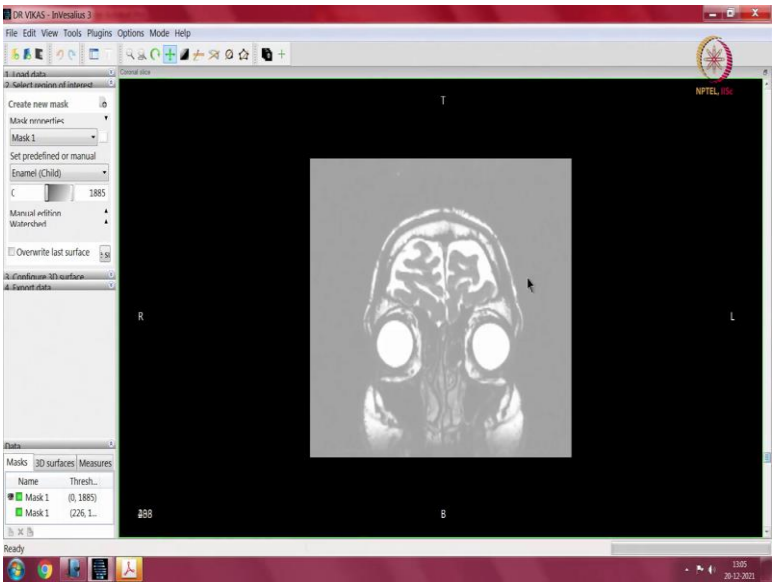

So, we go front. Yeah, so that is the eye. So, the eye is a useful landmark for people who are seeing these images for the first time or who would need to work with these images on a regular basis.

So, when you see the eye, you can sort of orient yourself. Remember that the image is looking towards you. So, left is this side, this is the left eye, right eye then we have to go back a bit to identify some more structures. Yeah, I think this is fair enough to make a understanding of the left sorry right superior frontal gyrus, middle frontal gyrus, inferior frontal gyrus.

So, superior frontal gyrus, middle frontal gyrus, and this whole stuff here is the inferior frontal gyrus. So, people who had been skeptical of my 3D demonstration would understand why I started with 3D and not with this thing.

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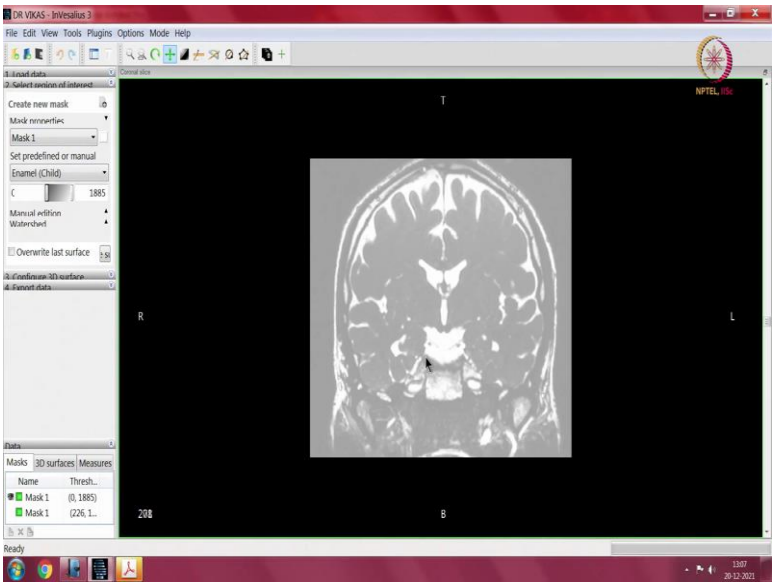

So, whatever be the amount of difficulty you have faced I would suggest that you sit through my classes on this if you are keen on understanding the anatomy of the brain. So, temporal lobe, again I told you about two sulci, three gyri. So, this is superior frontal sorry superior, middle and inferior temporal gyrus, yeah. So, this structure you see here with a lot of bumps that is the hippocampus.

So, hippocampus is on this side which is the medial part of the temporal lobe medial is towards midline. So, this would form the uncus, if this is the uncus and temporal lobe, uncus then this is the temporal horn again going back. So, this is the lateral ventricle lateral ventricle, third ventricle, temporal horn. Here again you can see this continuum.

So, if we trace this is the general subarachnoid space, general subarachnoid space goes between the frontal lobe and the temporal lobe and then goes deep. And so, this forms the insula. Same thing here, goes from the outside creeps in between the temporal lobe and the frontal lobe; frontal lobe here temporal lobe here and this forms the insula so insular cortex.

This is a bad section to you know comment upon the motor cortex and things like that because you can hardly make out anything. This is the corpus callosum. So, corpus callosum formally is only so much. These two bulges which are seen over here which are separating the lateral ventricle and the third ventricle is the phonics. Go back and this

will be the atrium of the lateral ventricle, atrium going into the occipital horn; occipital horn on both sides.

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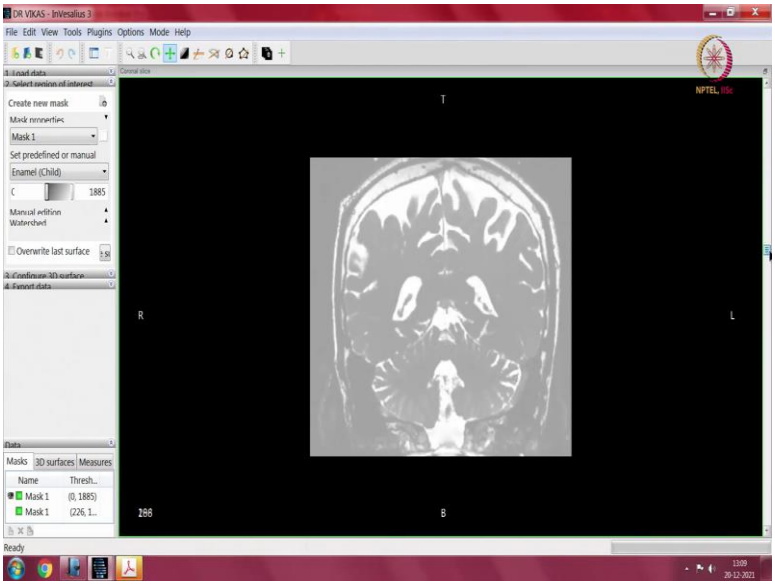

Yeah, so I think that is sufficient enough for a description. So, may be a little more clearer is the uvula and how do I get the tonsil? Tonsil is in the other direction. So, that is yeah, I think that is a clearest view of the uvula in the center and the tonsils and the periphery cerebellar hemispheres.

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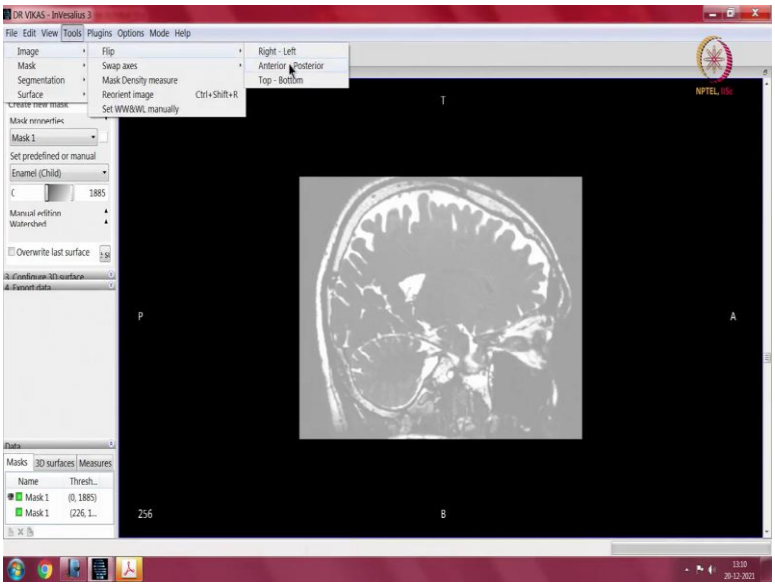

So, so that is about the coronal section. For showcasing I need to flip anterior to posterior.

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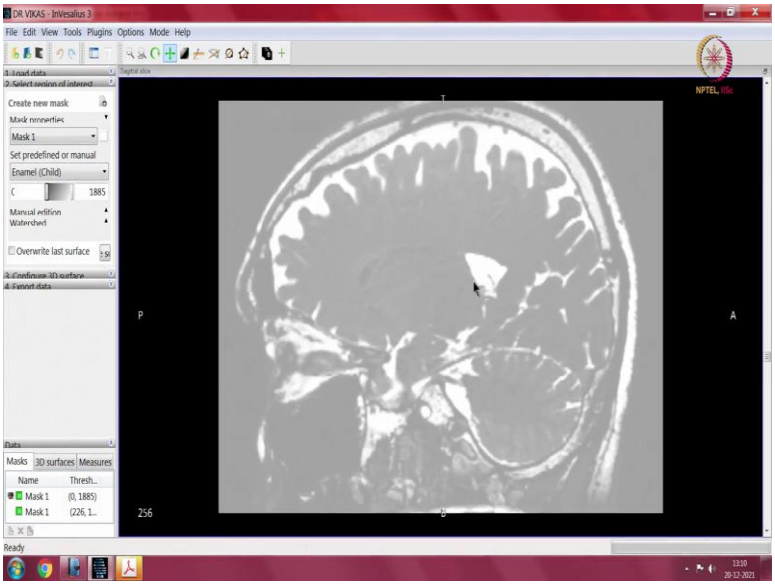

Yes, so this is anterior, now I have done an image flip on this, the marker still shows at posterior and anterior what structures are seen now would need to be explained. So, a more distinct understanding of the tentorium, the supratentorium is over here. So, this black line, which is separating the cerebellum, cerebrum from the cerebellum is the is the tentorium. So, tentorium, cerebellum, cerebrum. They are going out, just seeing whether I can highlight the motor cortex over here, not possible.

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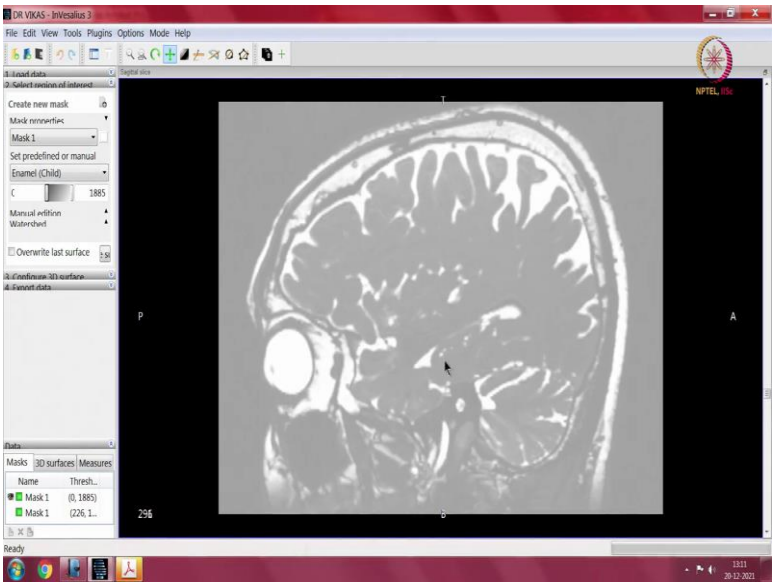

So, hippocampus again seen over here, it is temporal horn tracing it up. So, this forms the lateral ventricle. So, that is the full lateral ventricle this bulge which is seen as the caudate head again you cannot make out the caudate head from the rest of the stuff because of the sequence which is used. But I did not come to the midline for that purpose, I came to the midline for this.

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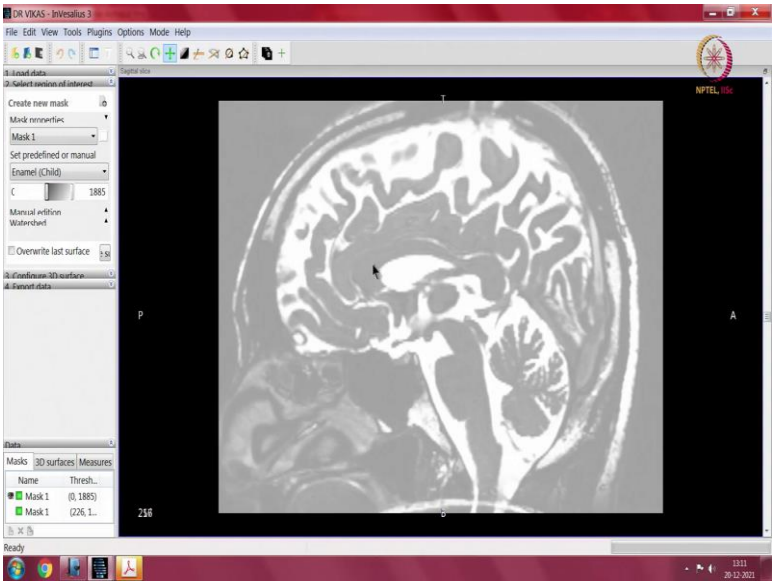

So, this is the corpus callosum we have discussed in the T 1, above the corpus callosum is a gyrus. That is the cingulate gyrus and above that is the cingulate sulcus. So, cingulate

sulcus goes all the way up here all the way up here and then goes to the midline, where is the midline?

Yeah, so I need to appreciate this thing. So, this is the part which is here and then it goes back over here. So, this is the central sulcus which is coming from the other side into the midline.

So, there is another sulci which is seen only in here, is this one. So, the calcarine sulcus which is where the vision is handled is here, this one. So, there is the calcarine sulcus, this is where the primary vision that the cortical vision gets processed over here goes to several kinds of associatory areas in the other part of the brain. But this is called as the visual cortex damage to this causes a lot of significant field visual problems injury to that.

So, this would be the lingual sulcu,s this is the parieto occipital sulcus, see notice that it is going all the way up to the center as in the periphery under the skull and that is the parieto occipital sulcus. So, I feel I have covered most of these brain related structures, what is actually remaining is I would like to highlight something on the other structures. I have told you only so far about the eye.

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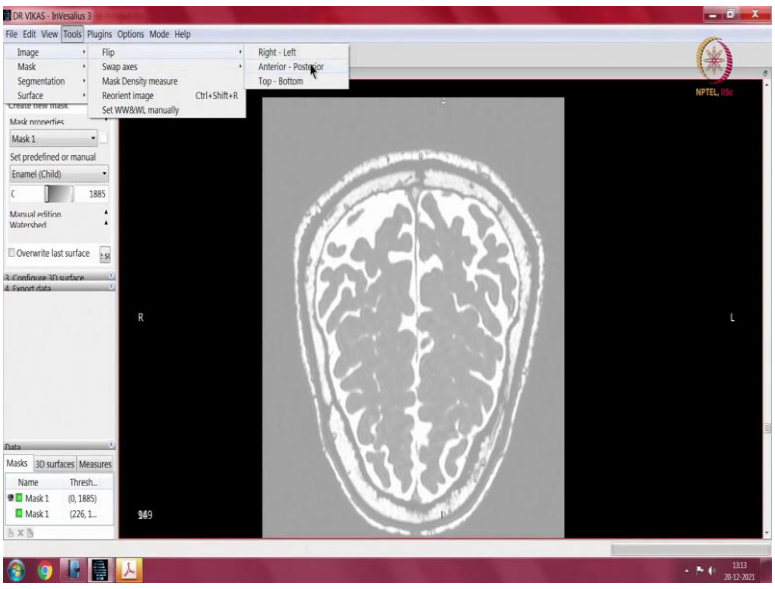

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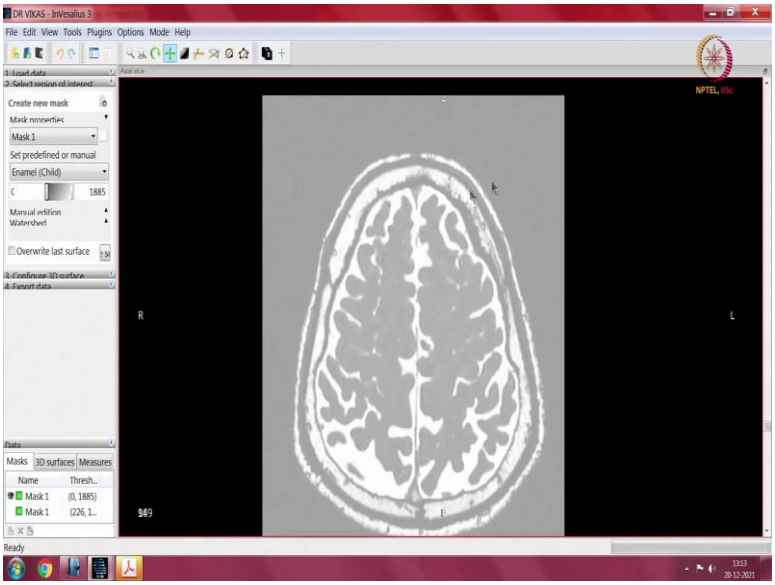

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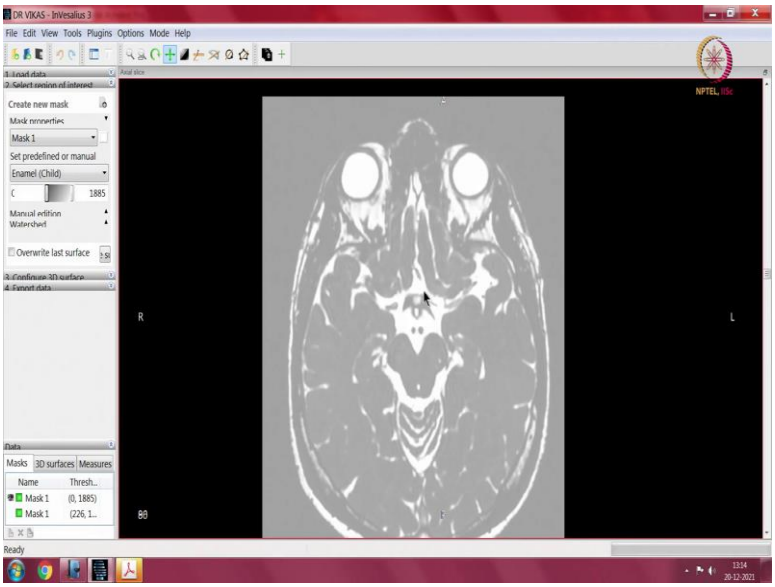

So, what other structures can be seen as something which we can spend some time I showed you the eye, nose and stuff like that I also showed you optic nerve. So, this is the optic nerve. Now, when the optic nerve comes back from the eye, so this forms the chiasm. So, chiasm is the junction between the two optic nerves, two optic nerves. So, this is the chiasm coming from the eye and then splitting back into two structures which is the optic tract.

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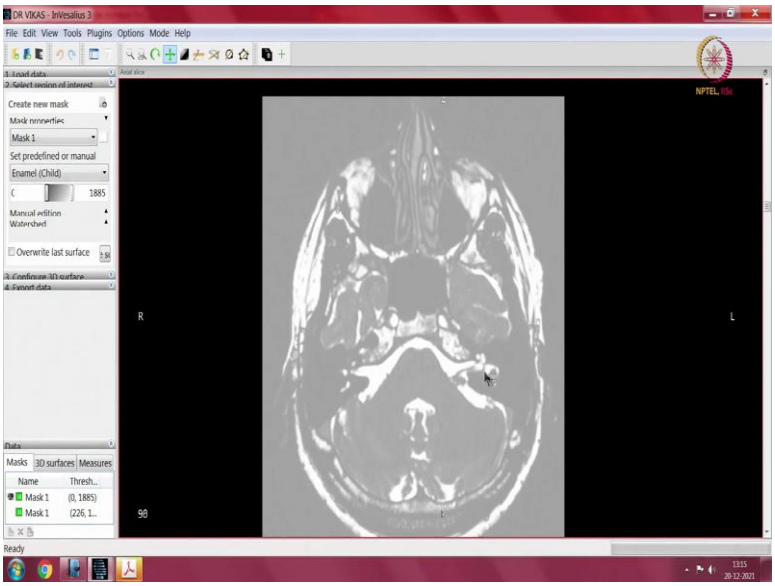

So, the optic tract goes back into the brainstem goes to the colliculi and from there on goes across the posterior part of the corpus callosum into the visual cortices of both the sides. So, that is cranial nerve number 2, let us see if we can identify the remaining cranial nerves.

So, here would be cranial nerve number 1, it is indistinguishable in this section. So, we will not bother about that. The other structures which I would need to show you is cranial number 3 which is going right into the cavernous sinus over here.

So, cavernous sinus third nerve. So, this is the third nerve on this side going into the cavernous sinus, fourth nerve would be a bit difficult to notice here yeah. So, this is the fourth nerve I think because it is difficult to comment in this sequence. Lower down this is fifth nerve, fifth nerve, fifth nerve, fifth nerve both the fifth nerves. Sixth nerve here I am not sure that is the imaging is showing. The sixth nerve this side, it is not. I am not able to make out the sixth nerve, sixth nerve goes somewhere there.

Seventh and eighth are more easily identifiable because lower down they are going into this, so this is the cochlear, this is the semicircular canals. And they are responsible cochlea is responsible for hearing, semicircular canals of balance, same thing on the opposite side, cochlea here for hearing semicircular canal. Semicircular canals you can see these round structures.

So, there is a circle here, half a circle here. Then we have one more half a circle in two different planes. So, you cannot make out all of that in all the in a single sectional imaging. What goes out through the internal acoustic meatus is the seventh and eighth nerve. So, seventh nerve which is the facial and eighth nerve.

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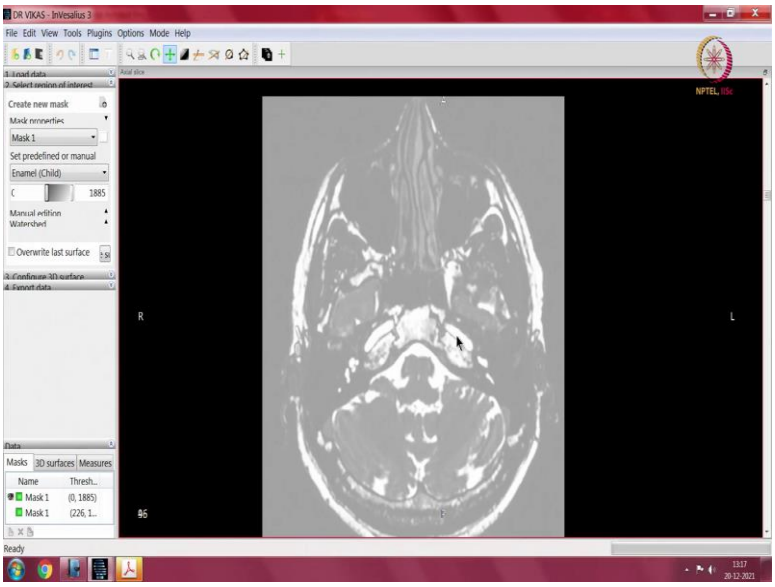

We go further down and this is the jugular foramen. So, through the jugular foramen goes the ninth, tenth and eleventh. The twelfth nerve is more difficult to make out, here you can make out small bulges, small depressions here and that is the twelfth nerve. So, these are the cranial nerves which you can see, these are the blood vessels.

So, these white things on both sides are the blood vessels. Carotid artery which is there in the neck. So, when you do stroke evaluation this is the target of your evaluation do processing and finding out how these vessels look like in your imaging.

So, this is the petrous carotid, then petrous carotid going into the cavernous sinus. So, this is the cavernous sinus carotid on this side, not very distinct. So, yeah because there is there is blood flowing through the carotid and that is why you cannot make it out very clearly. So, this is the carotid which comes into the brain and then it forms the middle cerebral artery, and the anterior cerebral artery is somewhere here.

So, this is the anterior cerebral artery. I just want you to have an idea; obviously, there are no questions going to be asked on where whether you can recognize these things on a

given image. For people interested you would have to jump ship, come into medicine finish medicine and come into neurosurgery where I can teach you all of that stuff I could not make light reading for the current course.

So, I think I have covered a lot of the structures which I need to showcase here you can see these things over here which is the sagittal sinuses, and these sinuses are the venous sinuses of the brain which carry blood from the brain into the heart. Ventricles, this stuff which is projecting into the ventricles, small things which are they are the choroid plexus.

So, choroid plexus is the fourth ventricle then this is the aqueduct you can see it is a tube which is surrounded by brain aqueduct and yeah, so that is where the communication is happening with the third ventricle. So, this is third ventricle opening up into the aqueduct, aqueduct, aqueduct, aqueduct, aqueduct, aqueduct, aqueduct, aqueduct and then it is opening into the fourth ventricle, this is fourth ventricle it opens to the outside through the foramen of magendie here and into the foramen of luschka over here.

So, that is the foramen of Luschka, foramen of magendie we go up it forms the aqueduct, aqueduct is the third ventricle. So, this is the thalamic adhesion. So, I started my 3D modeling with both thalamus and the thalamic adhesion, it is also relevant.

So, for people who are doing deep brain stimulation studies, it is an important landmark. So, here you can see the third ventricle communicating over here, this is the phonics. So, phonics which is coming out from the hippocampus, sort of coming out from the hippocampus and lateral ventricle, third ventricle, junction this is the foramen of Monro, foramen of Monro.

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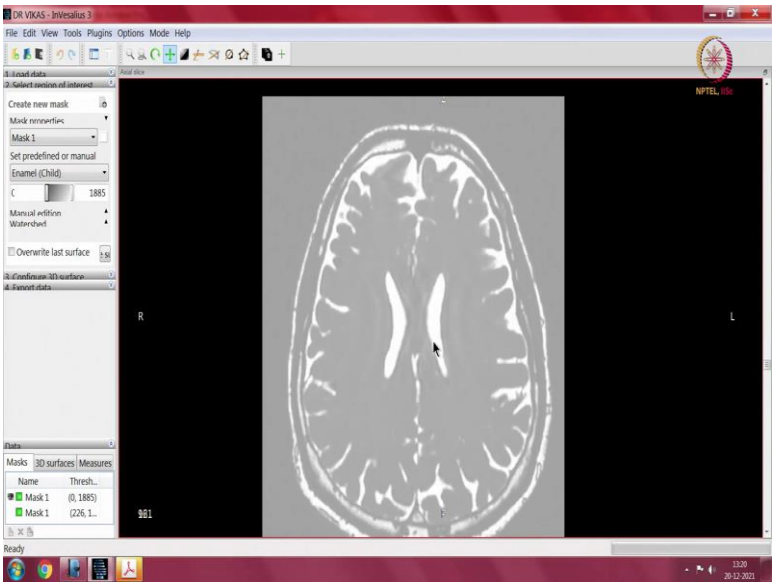

So, lateral ventricle again, lateral ventricle again and that is the left and right lateral ventricles. So, this is a right lateral ventricle, left lateral ventricle, this is the septum between the two and this is the foramen ok.

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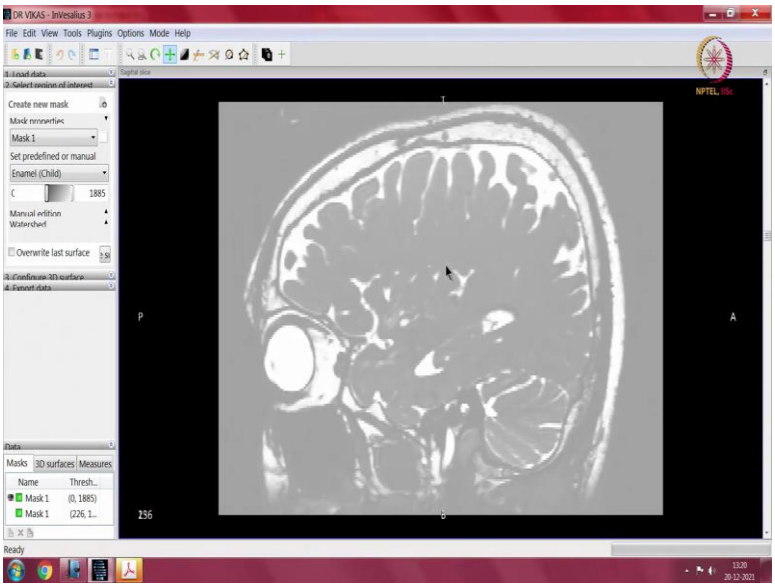

Sagittal section, I had to show the pituitary and the stalk, in my very early classes I spoke to you about how the pituitary is one of the other information systems which is present within humans and how the pituitary actually controls a lot of stuff on the long term. So, this is the pituitary gland, and it is connected to the brain through something called as a

pituitary stalk. So, it is outside of the brain, but it is connected to the brain. So, that is the pituitary, we go back to the optic nerve over here.

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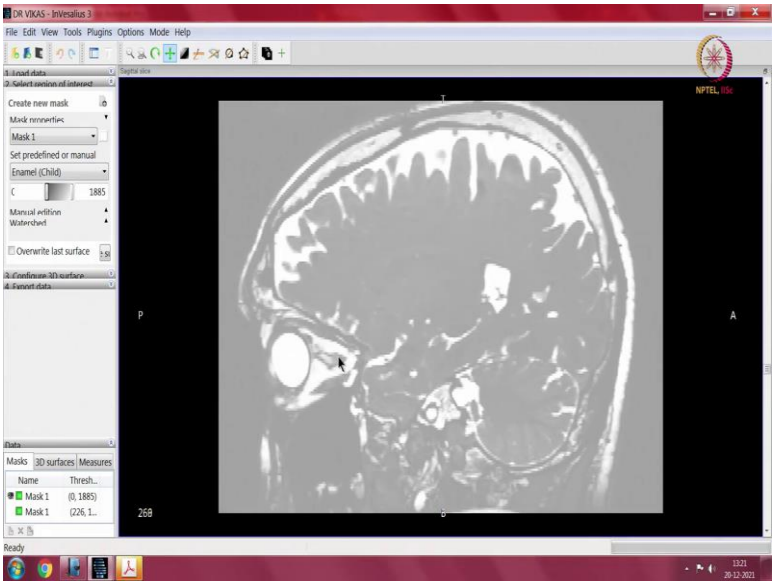

So, optic nerve curving over here and we trace it back, it comes back through here, here and here and here and that is the optic chiasm. So, these are sectional imaging. So, you can make out that it is closely related to this region and that is the region of the hypothalamus. So, hypothalamo pituitary axis is the region of the hypothalamus, this is the region of the optic nerve. The other structure which I am trying to showcase here is the olfactory tracts, olfactory tracts are somewhere over here and these are the olfactory tracts a one side, olfactory tracts on the other side. So, those are the olfactory tracts.

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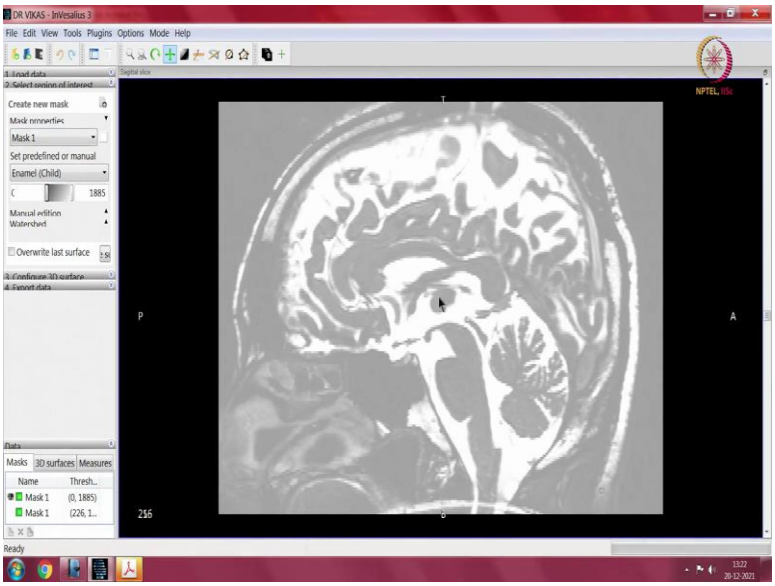

Yeah, so this is a superior colliculus this is inferior colliculus and there is maybe a single section where I can show you the aqueduct. So, that is the third ventricle the inter thalamic adhesion, this is a section of the midline right. So, we see corpus callosum over here, splenium of the corpus callosum, the genome of the corpus callosum, eye is this side, nose is here, splenium is here, genome is here, this is the corpus callosum, this is the fornix, the thalamic junction.

So, this is the third ventricle; third ventricle, fourth ventricle and the continuation between the two which is the aqueduct. You can distinctly see the pons separate from the brain medulla. Upper part of the medulla forms the fourth ventricle. Fourth ventricle is somewhere up to here, this should be the obex. So, half of the medulla is part of the fourth ventricle, half of the medulla down is not part of the fourth ventricle continues down as the spinal cord. This would be the pyramid, and this would be the cerebral peduncle this is the mammillary body.

So, that is it I think that is a very elaborate description of the imaging features of the human brain. Revising this stuff, I have described about imaging, I have described about sectional imaging. I have described MR sequences, magnetic resonance imaging sequences, and their relevance. I also showed you how same person imaging sequences look very different.

So, you cannot say that you know you done training on T 1 images and then you transfer it on to Sys imaging which looks very different. You can do of course, but you know the imaging sequences are designed for interpreting different stuff. And the reason of going through this exercise in the way in which I went through is to make you understand that what is the relevance of different sequence imaging, what output you get is very different, you cannot see all of that in one single sequence.

So, interpretation is different the structures which you can appreciate and understand are different that is in reference to sequences and also the relevance of sectional anatomy. So, sectional anatomy is very different from 3D anatomy, especially in the imaging context because each sectional series, so axial series, the coronal series and the sagittal series, all give you very different information they are the same it is the same stuff it is the same brain.

But when you see these images, you should make a point of looking at it thoroughly to understand things which are there in a particular sequence and appreciating and doing whatever stuff else. So, the, I think with that I think I can conclude this part of the story and will proceed from there on.

Thank you.