American Brain Tumor Association Webinar

Advancements in Radiosurgery

>> Today's webinar is on advancements in radiosurgery and will be presented by Steven Chang, MD. If you have a question you would like to ask, type into the question box on the control panel on the right hand side of your screen. Dr. Chang will answer questions at the end of the presentation. Tomorrow you'll receive an email asking to evaluate this webinar very briefly. If you can take a moment to send in comments, your feedback would be very much appreciated and is important.

This webinar is being recorded. The recording will coast to the ABTA website shortly. Participants will receive the link in a follow-up email once the webinar is available. Let's pause for a moment so we can begin our webinar recording.

>> The American Brain Tumor Association is pleased to welcome you back to our webinar series. The webinar discusses advancements in radiosurgery sponsored by Accuray. I am Andrea Garsis, the program manager at the American Brain Tumor Association and I'm thrilled to introduce our speaker, Dr. Steven Chang, MD, professor and vice chairman of neurosurgery at Stanford University. His interests include surgical and radiosurgical treatment of tumors and vascular disease of the brain and spine. Dr. Chang received his medical degree from Stanford University and also completed his neurosurgical training at Stanford. He is the author of more than 280 peer-reviewed publications and book chapters. Thank you so much for joining us. You may now begin.

>> Thank you. I'd like to thank the American Brain Tumor Association for this opportunity for me to present this information. I am going to talk about advances in radiosurgery and I will break this talk up into three different components. The first component is to describe what radiosurgery is so that the listener today understands the term radiosurgery. I'll also talk about the various different types of radiosurgery devices or machines that are available. The third and largest portion of my talk is to provide examples of the various types of tumors that we are able to treat with radiosurgery at the present time.

>> The first issue is, what is the actual definition of radiosurgery. Because when patients and family members hear the term radiosurgery I think they are overwhelmed by the surgery component. Especially when talking to a neurosurgeon, it implies that radiosurgery involves some surgical procedure. What radiosurgery is – it's not a conventional surgery done in the operating room – it's an outpatient, noninvasive treatment. A way of delivering highly focused beams of radiation through a target. In the case of a brain tumor, we would be delivering these focused beams of radiation to a brain tumor. I describe these beams of radiation like a laser beam. Or if you're listening to a presentation and the speaker were using a laser pointer and pointing to a very specific part of the slide, that is the concept with radiosurgery. It's a very precise delivery of narrow beams of radiation to the target. It's a highly

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effective treatment for many types of brain tumors. I'll show many examples today of the types of responses we see. In many patients, radiosurgery is an alternative to conventional surgery. So patients will come in and have the option of either radiosurgery or conventional surgery for their tumor. In some cases we actually combine radiosurgery and conventional surgery to achieve the best outcome. So in these situations a combination or hybrid therapy often gives the best results.

>> This is a slide that shows a simple illustration of a brain tumor. You can see here it's the circular structure in this patient's left frontal lobe. We are looking at a horizontal slice of the brain here. You can see the brain tumor is located here. In this cartoon of the patient's head -- it's a computer-rendering – you can see various light blue lines coming in from various different angles. They represent the various beams of radiation. They all coalesce at the tumor so you’re able to deliver a concentrated beam of radiation to kill the tumor.

The timeline of radiosurgery goes back quite a ways. When people hear the term radiosurgery and once they understand it, it sounds kind of high-tech, but the actual term radiosurgery was developed back in 1951 by Dr. Lawrence Leksell. By the late 1960s, the first gamma knife radiosurgery device was developed. There have been several different iterations since then. In the early 1980s, proton beam radiosurgery became common. It was done in the United States and by the mid-80s the first linear accelerators (abbreviated LINAC), became online and by 1994 we at Stanford had the first Cyberknife machine developed. This is just a brief timeline on radiosurgery to give you some historical perspective.

>> The source of radiation among these various devices is somewhat different. From the tumor standpoint, the tumor sees a specific dose of radiation and does not really know the source of the dose. A gamma knife uses radiation, a linear accelerator uses x-ray protons and a proton radiosurgery device uses accelerated protons. So I'll spend one or two slides on each of these devices. Often times when people talk about these machines, they talk about the various companies that developed the radiosurgery machines. So Cyberknife is developed by a company called Accuray. Brain lab is associated with the Novalis brand, and there’s a variety of companies working on the proton beams.

So a couple of slides on the physics of radiosurgery, and I don't want to make this a very complex discussion here, but I want the audience to understand how the radiation is produced. So for a linear accelerator radiation device, the machine accelerates electrons to strike a metal target and this collision creates an X-ray beam which is delivered to the patient. So this is the linear accelerator. Electrons are accelerated down the linear accelerator and strike a metal plate here. The actual striking of the metal plate by electrons, that collision creates x-ray beams which are given off and can be directed to the patient. A gamma knife uses radioactive cobalt. This radiation is always on, so when a patient is being treated by the gamma knife, their head is inserted into the gamma knife device and small openings in the lead shield are temporarily open, allowing the radiation to be targeted to the tumor. Proton beam devices, they're not as prevalent as the gamma knife and linear accelerators, but in principle they accelerate protons at very high speed, almost at the speed of light. Then they’re delivered to the patient to reduce the radiation.

>> So a lot of my experience focuses on the Cyberknife. That is the machine we use at Stanford to do radiosurgery. The Cyberknife is a linear accelerator – it is a LINAC machine. It is frameless and delivers beams of radiation by moving around the patient. This is a cartoon of a Cyberknife machine. There is a table that the patient lies on during the treatment. This is the lightweight linear accelerator that moves around the patient. It is able to move around the patient because it's mounted to a robotic arm. This is similar to those robots that you see on an automobile assembly line that install parts on automobiles. So this robot moves around the patient at various different positions. This radiation is then delivered to the patient. During the actual patient treatment, the patient's position is tracked in real time. There are X-ray sources in the ceiling that capture digital images of the patient's position in real time. So if during the treatment if the patient were to wiggle a bit or move, that motion is detected for and compensated for by the machine. In other words, we're then able to deliver the radiation with less than 1 mm of error by compensating for the patient motion during the treatment. This is the newest generation Cyberknife – Cyberknife copy M6 machine. This is just a cartoon of the M6 machine. There is a patient treatment table with the robot shown here. During the patient treatment, a patient typically wears a soft plastic mask. This is to minimize the motion of the patient so that there are not large amounts of motion. If there are, it takes the machine longer to track the patient position. We try to minimize this motion by wearing this soft plastic mask.

>> I'll talk specifically about the various types of tumors that we treat with radiosurgery. I picked a variety of tumors to provide a broad example of both benign and malignant cancerous tumors. I've also picked a few types to emphasize some points I want to make today with respect to radiosurgery. The first type of tumor I want to talk about is brain metastases. These are tumors such as lung cancer, breast cancer, melanoma, renal cancer, colon cancer, cancers that come from a different part of the body and travel up to the brain. They're called secondary tumors because their primary site is somewhere else in the body. The secondary site is in the brain. So brain metastases represent the largest section of brain tumors treated with radiosurgery machines. That is because cancers are quite common. This is an example of the patient with a lung tumor. This is a vertical view of the patient's brain. This is the top of the head. This is the patient's right side and this is the left side. This is a vertical slice through the patient's head this is what things look like prior to radiosurgery treatment. You can see there's about a 1 inch diameter tumor shown here in white. This is what it looked like prior to treatment. So this tumor is close to the surface of the brain.

>> You could argue that this can come out with microsurgery in the operating room. But microsurgery is an invasive procedure and perhaps a patient may have some contraindications to conventional surgery. Maybe their heart or lungs cannot tolerate general anesthetic or perhaps their cancer throughout their body is such that they are not an ideal candidate. So this patient was treated with radiosurgery. You can see two years after radiosurgery, the area where the tumor was located is now showing some scar tissue and a pretty dramatic response in terms of tumor shrinkage. Unlike whole brain radiation, radiosurgery can be repeated. So if this person were to develop additional tumors a year or two later after the first tumor was treated, we can treat those additional tumors with radiosurgery. So you're not limited to a one-time event such as you are typically with full brain radiation.

>> The most common benign tumor we see in the brain is called a meningioma. Meningiomas represent about 15% of brain tumors and they usually occur in middle-age or later, and they are more common in women than in men. So a classic patient would be perimenopausal or post-menopausal. Meningiomas grow along the interlining of the skull. So here's an example of a patient's brain. We're looking at the brain here – this yellow arrow is pointing to this white spot which is a meningioma. It's growing off the interlining of the skull. So were talking about a benign tumor that can be removed with surgery, three hours of surgery under general anesthesia, three days in the hospital, and several weeks of recovery from the fatigue of the anesthesia. Or, this tumor is small enough to be treated with radiosurgery. That's what was done in this case. You can see during the radiosurgical treatment we outline the tumor and deliver a very precise dose of radiation to the tumor. You'll see there's a dotted line around the tumor here and the solid line around this area, is the area to which the radiation is delivered. You can see how closely the solid line matches the dotted line in this particular patient. You'll see some other dotted line structures here – these are what is called critical structures. These are those structures of the brain that we are trying to minimize radiation to.

>> So in this case this is the brainstem and we obviously want to minimize radiation to that area. This structure here is called the optic pious. This is the right optic nerve shown here. So we're telling the computer during radiosurgery that we're giving a lethal dose of radiation to the tumor here, but minimizing the radiation to other structures here. The computer will calculate a program that allows us to deliver the radiation precisely to the tumor while minimizing radiation to these other structures. This is what the patient looks like a couple years later. Meningiomas don't shrink a lot. Benign tumors often die at the current size and we look for no growth. So there's been no change in the tumor over the treatment. This tumor will not grow for the patient's remaining lifetime. This is one slide on the outcomes. So for meningiomas, we have a pretty good kill rate at Stanford: 92% success rate in halting tumor growth. That's pretty much what other people are reporting here.

>> I want to talk a little bit about perioptic tumors because this is one of the areas in which radiosurgery potentially has a very distinct advantage over conventional surgery. Perioptic tumors are tumors around the optic nerve, which is the visual nerve. The one that comes out of the back of the eye and connects the eye to the brain. It is the nerve that allows you to see things. To see the television, to read a book, to see things when you look out the kitchen window. So any structure around these nerves, if you're treat them with surgery or radiation, the primary risk is potential injury to the optic nerve, resulting in visual loss to the patient. So here's a case example of a meningioma involving the optic nerve. Let's talk about the anatomy first. This is the tumor here shown in white. These two optic nerves are these grey bands running vertically. This patient underwent conventional surgery and at the time of surgery the surgeon removed a majority of the tumor. He wasn't able to remove the small part of the tumor because it was stuck to the optic nerve. He was fearful of injuring the optic nerve during the actual resection and reelected to leave this small part of the tumor behind and refer the patient for radiosurgery.

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>> The patient was treated with radiosurgery and you can see following the treatment, the tumor not only has decreased in size, but the optic nerve also looks fine. In this patient, the vision was unchanged. So we were able to preserve the patient's vision while killing the tumor. Not all tumors around the optic nerve are benign. This is an example of cancer. This is the optic nerve on the right and this is the optic nerve on the left. This is a malignant cancer that has spread up to the region by the optic nerve. You can see shrinkage in the tumor here. So before the tumor was thicker in this vertical dimension and now it is thinner. Before, it was touching the optic nerve and now here's the optic nerve and there's some space in between. So in this case the tumor has decreased or shrunk away from the optic nerve.

>> Here are a couple of cases in which the actual treatment not only controlled and shrunk the tumor, but actually resulted in improvement in vision. This is a patient with a pituitary tumor shown here, prior to treatment. This is the tumor after treatment. There's been some shrinkage in the tumor and it's right next to the optic nerve. This is the result of what we call the visual field. So OS refers to the left eye and OD refers to the right eye. When you do a visual field test, if you have normal vision, that will show up as white. Part of the eye that has difficulty seeing or with no vision, appears black. You'll see in this left eye, prior to treatment, the patient had visual loss in about one quarter of the eye. After treatment of this particular tumor, the vision in the left eye actually improved and there is less black in the area. This quadrant here, this quarter of the pie, represents the visual improvement in the left eye. In the right eye, we had a little bit of visual loss, but after treatment this improved. Not only did we control the tumor and kill it but we also improved the patient's vision.

>> Here is another example of a patient with a tumor. This is a meningioma along the left optic nerve. If this were treated with surgery, the patient would likely lose his vision in the eye. Obviously that was not an appealing option to the patient so this patient instead underwent radiosurgery. After the treatment, you can see that the tumor is smaller in size. The optic nerve is running through the tumor. So one would expect if you radiated this tumor, you might hurt the vision in the vision nerve. This is the vision in the patient's eye prior to treatment, and again black is bad. So the patient had very poor vision in the bottom part of the eye, yet after treating the tumor, the patient's vision actually got better. So instead of doing a conventional surgery, doing radiosurgery not only is a noninvasive treatment, but in some instances we can actually see visual improvement in the patient's eye.

>> The next type of tumor I want to talk about is called a glomus tumor. These are quite rare, but I use this type of tumor to show an example of how much better radiosurgery can be than conventional surgery in certain kinds of tumors when it comes to minimizing side effects of the treatment. So glomus tumors are tumors close to the base of the skull. You'll see the tumor that's wedged into the bottom of the skull and this tumor is treated with radiosurgery. Here’s another tumor, grey is the brain and white is the skull and this tumor is wedged into the skull. These tumors are routinely treated with radiosurgery. When we treat these tumors at Stanford, we are getting 100% control rate. And when we look at the rest of the literature of radiosurgery as a whole, what we call a meta-analysis, studying everything in the literature, the control rate of radiosurgery is 98%. The complication rate with radiosurgery for these tumors is only about 3 to 4%.

>> Now let's talk about regular surgery for glomus tumors. Regular surgery, the control rate is 83% - it's good but not as good as it is with radiosurgery. But regular surgery has a 48% complication rate. Looking at medical literature with the various studies and 539 patients that underwent surgery, 261 had complications from the surgery. That compares to just 15 out of 345 patients in the medical literature that underwent radiosurgery. This type of tumor has really emphasized the take-home message that, in certain types of tumors, we have a very significant reduction in the complication rate when we treat these patients.

>> This is an acoustic neuroma and this represents about 8% of brain tumors. It is a benign tumor along the hearing nerve. It compresses the hearing nerve. Because patients often present with hearing loss, these tumors are often referred to as acoustic neuromas. These are also down along the skull base pictured here, and you can see the tumor is outlined in red and for the radiation dose you'll see there's a very tight contouring or overlap of the radiation delivered to the tumor. This cartoon shows a patient's head and you can see the various different beams coming in from many different angles. Two target the radiation delivered to the tumor.

>> Here are the results of our control rates with radiosurgery at Stanford. This is a Kaplan-Meier curve which determines how successful you are in treating the tumor. So in our experience with almost 400 patients with this type of tumor, we had an almost 96% rate in killing the tumor. For very small tumors we were at 98%. So not only are you having a high success rate overall, but if the tumor is small, you have a higher percent rate. We know that for these type of acoustic neuromas, you have better results treating them when they're small. This is why some patients may elect to treat these tumors while they're small rather than observing them and waiting to treat later.

>> As mentioned with these acoustic neuromas, they often present hearing loss. Patients want to know if they undergo radiosurgery, what is the chance that they can keep their hearing, particularly if the patient comes in with good or perfect hearing. Overall, there's about a 75% chance we can keep your hearing treating this tumor with radiation, it's better for smaller tumors, so for tumors that are small there's a higher chance at keeping your hearing than larger tumors.

>> With surgery the rate for keeping your hearing is much lower. For large tumors, undergoing surgery lowers your hearing preservation rate closer to. Radiosurgery is not only non-invasive, but also gives you a better chance at keeping your hearing than a surgical resection.

>> As mentioned towards the beginning of the presentation, in some instances we combine conventional surgery with stereotactic radiosurgery to achieve the optimal outcome. So this is an example of a patient who presented with an acoustic neuroma. This patient was having some problems with balance because the tumor was really pushing on areas of the brain pictured here. This patient also did not want to risk injury to the facial nerve. The facial nerve typically runs right along the edge of the tumor and is what causes movement in your face. If it is injured, you have a paralyzed face. In this particular case, we told the patient that you're having balance problems from pressure on the brain, so

you'll need to have survey to remove the tumor. But the patient said, I don't want to injure the facial nerve, can you stay away from that. So we did a combination treatment here where we did a surgical debulking: we did surgery to remove the part of the tumor that was compressing the brainstem, but we stayed away from the facial nerve.

>> This was the result after surgery, pictured here. We left the part of the tumor along the facial nerve because the patient was fearful of any risk of facial damage. Then, we treated this residual tumor with stereotactic radiosurgery. And three years later you can see there's no growth in that residual tumor. So again, remember a benign tumor, we look for tumor control. A benign tumor doesn't necessarily shrink. So this patient had preservation of the facial function, normal facial movement, but we were able to take the pressure off their brain and restore their balance issues. This is a good example of a patient in which they had combined surgery followed by radiosurgery.

>> Let's talk about malignant gliomas. This tumor would fall into that category. Gliomas are often treated initially with surgery followed by conventional radiation. Conventional radiation typically involves six weeks of radiation for your tumor. So you come in Monday through Friday for a total of six weeks which is 30 treatments. That's a significant amount of time for the patient to travel every day to the hospital or medical center for the radiation treatment. Particularly if a patient's prognosis is somewhat limited. If a patient has a nine-month prognosis and they spend six weeks or a month and a half receiving radiation, they have used 20% of survival after diagnosis just for radiation treatment.

>> What we pursued with radiosurgery is clinical trials looking at mechanisms to substantially decrease the number of radiation treatments. So at Stanford, we have a clinical trial looking at radiosurgery to deliver radiation to a malignant glioma after surgery. And instead of doing 30 treatments for six weeks, we do five treatments, Monday through Friday, for one week. So 30 treatments are not what is needed. We're replacing them with just five treatments. So shortening treatment time is actually improving the patient's quality of life because they don't have to spend six weeks of their life dealing with radiation – they just spend one week. This is how we constructed the clinical trial: we divided the tumors into small and large gliomas and it was a dose escalation trial, so we started the first patient with smaller doses. As we showed there was safety in delivering the radiation, we gradually increased it over time to use higher doses of radiation for these types of tumors.

>> I want to show a case presentation of a patient using five doses versus 30 doses of radiation. This 53-year-old female came into my office and complained of headaches and confusion and some speech difficulty. An MRI scan showed a 4 1/2 cm tumor in the left frontal lobe of her brain. This is what the tumor looked like on our MRI scan. This is a horizontal view of the brain with contrast. You can see the contrast-enhancing tumor here. There is some darker grey around the tumor, which represents swelling or edema, and you can visualize the swelling pushing the brain over. When we look at this tumor on a vertical view of the brain, this is a profile view of the brain. You can kind of see the mass of the tumor here. This patient underwent surgery first and after, we were left with this cavity of where the tumor was located. The patient opted for the five courses of Cyberknife treatments rather than 30 treatments

of conventional radiation. This is the treatment plan for the cavity we're treating and we're doing the radiation to eliminate any microscopic cells in that brain. These are the horizontal, vertical and profile views showing how we are delivering the radiation to the region where the tumor was located. I will show a couple of slides here. This is what the tumor looked like after surgery. The patient was treated with the five doses of radiation. You can see at one month, there is no progression. At three months, the cavity is getting smaller. At five months you can barely see the cavity there. At seven months there's just a little bit of scar tissue left. This is a patient for whom we were able to replace 30 days of radiation with just five days of radiation, because we have the technique.

I will close with about two or three examples of when we would not recommend radiosurgery. I don't want the audience to come away thinking today that every brain tumor can be treated with radiosurgery. So let's talk about certain cases when radiosurgery is not the best option.

>> The first situation where it's not an ideal option is, if there is a significant amount of swelling around the tumor in the brain. The medical term for swelling is edema. By looking at this scan here, we can see this tumor is a good candidate for radiosurgery. But when we look at the rest of the MRI sequences, like the T-2 sequence that looks for swelling in the brain, we can see the tumor is irritating the brain. If we were to radiate it, it may not eliminate all the swelling in the brain. Removing the tumor is probably the best initial treatment, because it would remove the irritation to the brain and make all of this swelling disappear.

>> Another example, is when there's a diagnosis in question. This patient has a tumor that's coming off of the interlining of the skull, typically thought of as a benign tumor. However, this patient had a history in the past of renal cell cancer. So that raised the issue of, could this be a metastatic cancer – could this be a renal cell tumor that spread up to the brain? And because we weren't sure if this was a meningioma or renal cell cancer, we elected to remove it. It was renal cell cancer and not a meningioma. So this was a situation where removing the tumor clarified the diagnosis for the patient.

>> The last situation in which we typically do not recommend radiosurgery is for tumors with significant mass effect. Mass effect means pressure on a brain structure. The tumor shown here is compressing the brainstem. The brainstem is normally a circle, but here it is a C-shaped structure because the tumor is really indenting. This was thought to be benign, but because it was compressing the brainstem and the patient was having problems with strength in their legs, the radiation does not necessarily shrink the tumor dramatically, so therefore it would not take the pressure off of the brainstem. So this patient underwent surgery to remove this tumor to take the pressure off of the brain.

This concludes my presentation. I want to acknowledge that have a large team here at our institution and I want to acknowledge all the other members of the team that are involved in treating patients with radiosurgery. I'm certainly not doing this by myself. These are the rest of the physicians and we have a number of coordinators and therapists that help us schedule and treat the patients. I'll conclude my presentation at this point and I'm happy to answer any questions you may have.

>> Thank you for that great presentation. If you have a question you'd like to ask please type and submit it using the question box in the webinar control panel on the right-hand side of your screen.

>> If you could talk a little bit more about short-term versus long-term side effects of radiosurgery.

>> Radiation by nature does not work immediately. If you had radiation treatment on November 1, the tumor is not dying necessarily by November 2. Radiation has a lag effect and for malignant tumors this lag effect can span across several months. For a benign tumor like a mini genome, it can take up to four years for the radiation to really kill the tumor. Side effects also do not occur necessarily right away. A side effect from the treatment can be swelling from the tumor as the tumor dies, which can cause swelling in the surrounding brain. If you have swelling in the brain you could theoretically have symptoms like headaches or head pressure. If the swelling is in a very specific part of the brain and has a specific function you could have symptoms related to that area of the brain. If it controls movement to the body you could very well have weakness secondary to the swelling. Symptoms related to swelling are almost always temporary, meaning once the swelling goes down and disappears, the symptoms are resolved. But the swelling can last for several months and is disconcerting to the patient if they don't fully understand the process of how a tumor dies.

>> Can radiation kill cancer stem cells? What is the risk of the remaining benign tumors turning malignant?

>> Good question. In terms of, can radiation kill stem cells, radiation can kill any type of cell. We're not able to identify a specific stem cell. We can't identify cells at the cellular level. So when you see a tumor on the MRI scan you're really talking about hundreds of millions of cells comprising a tumor that you can visualize. This no way to separate out a stem cell. If there is a stem cell in the area being radiated it would certainly be impacted. In terms of what is the chance of a cancer developing from radiation, this always is a possibility. It's quite rare with radiosurgery for treatment to cause a malignancy. It's so rare that the actual numbers are not well understood. It's thought to be somewhere between one and 5,000, to one in a 100,000 over the lifetime of the patient. So I typically pull patients, let's say one in 10,000 over your lifetime. That can still be scary for some patients – having a one and 10,000 chance of having a malignancy develop with radiosurgery after the treatment. But for those patients who are concerned about it, I try to put things in perspective. If you have surgery in the operating room for your tumor, you have roughly a one in 500 chance of dying as a result of the operation, either from complications of the surgery or even days after the surgery you could have a venous thrombosis, or a heart attack. You could have a variety of complications because of the surgery. You have roughly a one in 500 chance of dying during conventional surgeries. If you are a male you have a one in 10 chance of prostate cancer in your lifetime. And if you are female you have roughly a one in 10 chance of breast cancer in your lifetime. And over every decade that you've lived, you have a one in 700 chance of dying in an automobile accident. So all of those numbers put things into perspective. If you're really worried one in 20,000 chance over your lifetime of a malignancy, you probably should also not be driving because you have a greater chance of dying than you do from radiosurgery.

>> When the acoustic neuroma tumors necrotize, does the tumor shrink in size?

>> The answer to that question is, some shrink in size and it depends on the time period you're talking about. So if you're saying what percentage of acoustic neuromas increases in size is actually very few. If you talk about what percentage of tumors decrease in size over 10 years, it might be 50%. So when patients ask about shrinkage, I often have to say what timeline are we actually talking about. I also want to emphasize that the shrinkage of an acoustic neuroma does not necessarily mean that that patient will have a better outcome than a patient in which their acoustic neuroma dies at the current size and stabilizes.

>> What's the treatment protocol for the hypo fractionated treatment of gliomas?

>> By being a clinical trial, it’s not a protocol that's been universally accepted. Our protocol at Stanford is that we could replace 30 treatments of radiation with five treatments of radiation. Effectively giving higher doses of radiation for each of those five treatments, than you would get with each day of 30 treatments. So effectively were getting the same biological equivalent dose of radiation over five days rather than 30 days.

>> Can Cyberknife radiation be used several years after a tumor was treated with six weeks of general radiation treatment?

>> The answer to that question is, it depends. Because the question specifically was tumors in a general sense. It depends on the type of tumor and the size of the growth and where the growth is occurring. In general, many tumors can be treated with radio surgery after a conventional six-week course of radiation. Many of them can, but not all.

>> Can you speak about the neurocognitive effects of radiosurgery?

>> One of the advantages of radiosurgery, over what I referred to as whole brain radiation, is that radiosurgery exposes very minimal normal brain through the radiation. So with whole brain radiation by definition you expose the entire brain to the same radiation that the tumor gets. This can result in cognitive effects to the patient. With radiosurgery, the radiation is highly focused to the tumor. The normal brain is spared the exposure to the radiation and so typically we do not see cognitive effects in patients undergoing surgery. Because you are essentially not exposing the brain to the radiation.

>> Cyberknife treatments can spread over many treatments, while gamma knife can be done in a single treatment. What are the advantages and disadvantages please.

>> The gama knife requires a metal frame to be attached to your skull in most treatments. And because of that the surgeons are confined to limit the treatment in a single session. You can treat the patient in a single session and I would say that at least half of the patients are treated in a single shot, but because it's frameless, it does allow us the option to deliver the radiation over several sessions if we think it's

safer for the patient. So I showed a number of examples of tumors that were touching the optic nerve. We think that in those instances delivering the radiation over several sessions is the safest way to go. Some of those tumors which I showed there were tumors that gamma knife centers would feel a little bit more reluctant to treat because of the fact that the tumor was touching the optic nerve. So that allows more flexibility in terms of being able to choose multiple treatments if you need to. But you'll always have the opportunity to do it in a single session.

>> Is radiosurgery cost-effective?

>> The data and medical literature shows that it is cost effective on several levels. First, compared to conventional surgery in the operating room, radiosurgery is highly cost-effective because you no longer have the charges and costs associated with an operating room, and ICU, any inpatient hospital beds, anesthesia charges, things like that. So compared to conventional surgery, radiosurgery is highly cost-effective. Compared to other forms of radiation, it is very comparable. For example, IMRT Treatments are usually delivered over the 30 sessions. And this typically will cost more than a single session of radiosurgery. The other thing to keep in mind is that radiosurgery is an outpatient noninvasive treatment. So many hospitals these days are faced with overcrowding, overcapacity and not having enough beds in the hospital. You're essentially allowing the hospital to treat more patients expeditiously because we're not waiting for a hospital bed to open up.

>> Would a person be radioactive for a point in time after receiving radiosurgery?

That's a very good question, and it's a common misconception. The thought is that some people think if you get radiosurgery the radiation is somehow in your body. If you get a chest x-ray, the radiation goes through your body into the film and that's what the radiologists look at. There is zero radiation in your body after a chest x-ray or a mammogram. With radiosurgery it's the same thing, the radiation beam goes in one side of your body, goes through to the tumor and out the other side of your body and into the wall. So when you get off the treatment table after radiosurgery, you are not radioactive, you don't have any radiation in you.

>> Thank you all for joining us and thanks once again to Dr. Chang for this wonderful presentation. For more information on brain tumors to help understand a new vocabulary and access resources, call the ABTA Care Line at 800-266-2282. Let's pause for a moment to conclude our webinar recording.

>> We invite you back for our next webinar topic, Coping with Depression, Anxiety and a Brain Tumor. This webinar will be on Thursday, November 12 from 12-1 p.m. CT. A person diagnosed with a brain tumor can be at high risk for a diagnosis of depression and/or anxiety, particularly as he or she is undergoing diagnosis treatment and symptom management. These conditions can be successfully treated if they are diagnosed. Sign up for this webinar presented by Mary K. Hughes, CNS, RN from the department of Psychiatry at the University of Texas M.D. Anderson Cancer Center. She will describe the signs and symptoms and how they affect quality of life for a person living with a brain tumor. The detection of anxiety will be emphasized. This webinar will include an interactive Q&A with Mary Hughes at the end of the session.

>> This concludes our webinar. Thank you for joining us and please be sure to complete the evaluation survey you'll be receiving by email tomorrow. You may now disconnect.