CYBERKNIFE SPINE SURGERY
OVERLOOK HOSPITAL, SUMMIT, NEW JERSEY
Broadcast October 20, 2005

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NARRATOR: Welcome to Overlook Hospital in Summit, New Jersey. During today’s live webcast, neurosurgeon Brian Beyerl, MD, and radiation oncologist Louis Schwartz will perform a tumor ablation to the thoracic spine using the revolutionary CyberKnife. CyberKnife stereotactic radiosurgery treats previously inoperable tumors of the brain, lung, liver, pancreas, prostate, and pituitary. The CyberKnife is exceptional for its accuracy and minimally invasive characteristics. A combination of sophisticated software and sensors create an accurate image inside the body. The robotic arm then delivers beams of radiation to the tumor. Today’s program is part of Overlook Hospital’s ongoing educational efforts to bring the latest information in CyberKnife stereotactic radiosurgery to patients and physicians. During the program, you may send your questions to the OR surgeons at any time. Just click the MDirectAccess button on the screen.

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LOUIS SCHWARTZ, MD: Welcome to the Overlook Hospital radiation oncology department, where we have our CyberKnife. Sitting next to me is Dr. Brian Beyerl, the co-director of our CyberKnife program. I’m a radiation oncologist. Dr. Beyerl is a neurosurgeon. Today we are treating a patient who has a metastatic tumor from a breast cancer. The tumor has spread to her spine and the concern is the tumor will weaken her spine and that she could develop paralysis as a result of weakening the bones around the spinal cord. Normally we would treat this with standard radiation treatment; however, this patient has previously received standard radiation treatment and that is not an option for her. The only option, radiation-wise, is the pinpoint CyberKnife treatment. Our patient is currently on the table, receiving her therapy. I wanted to introduce two of our therapists, who are at the machine. That is Joanne *Winnick-Verugo, who is our chief radiation therapist, and sitting next to her is Bonnie *Pine-dePertilio. They both work together to operate the computers controlling the CyberKnife. At this time, we’d like to give you a brief view of the CyberKnife program and Dr. Beyerl will introduce that to you.

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BRIAN BEYERL, MD: Thank you, Lou. I just also want to welcome everyone to the webcast. We have a very understanding patient that really is very motivated to expose this technology to patients that may not even know that they are candidates for the therapy, so we want to thank her for her generosity to share her story and share her treatment. Even without being exposed to a webcast, it can be anxiety-provoking, so we want to thank her and give her our support.

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I want to give you an overview of what CyberKnife technology is all about. CyberKnife technology is really part of the larger technology of stereotactic radiosurgery and I want to show some slides now to give you a sense of what it’s all about. I think you should be able to see the slide now. What you see here is Lars Lexel. Probably 30-40 years ago, Lars Lexel was a Scandinavian scientist. He really developed stereotactic radiosurgery as a form of pinpoint treatment for a variety of conditions. In the past 25-30 years, there have been basically three forms of radiosurgical systems that allow us to provide pinpoint radiation to targets and in the past within the brain, so for the first three of these forms of treatment or the three technologies that you see on the slide — the gamma knife, the cyclotron, and the linear accelerator — we really could only use this technology for lesions in the brain. The gamma knife was the piece of equipment that was developed by Lars Lexel. The cyclotron is a very large piece of equipment that’s really only centered at less than a handful of facilities in the United States and again is another way of providing stereotactic radiosurgery, but on a more limited basis because of the size of the equipment. In
the late 1980s, a new form of stereotactic radiosurgery delivery was developed, actually at Brigham & Women’s Hospital in Boston, and that was to use a linear accelerator to provide pinpoint stereotactic radiosurgery. That’s the third one on the slide. So the linear accelerator-based system to deliver radiosurgery was really the most effective form of therapy, in many ways, for community hospitals because they could use a linear accelerator that was being used for other forms of radiation and adapt it to the pinpoint stereotactic radiosurgery, so the linear accelerator system is what we introduced to Overlook Hospital in 1995 and, in fact, we were the first stereotactic radiosurgery program in New Jersey at that time, so we set up our linear accelerator program. Then the fourth radiosurgical system is that of the CyberKnife. There are other systems as well, but these are the main systems. So they all provide basic pinpoint stereotactic radiosurgery, but as you’ll see as we go along, there are very definite advantages to the CyberKnife over the other systems.

Here is a slide that gives you kind of a schematic line drawing of what these older systems are like. The one on the right is the gamma knife and the one on the left is the linear accelerator-based system that we’ve had here at Overlook since 1995. You can see on the right hand side, the gamma knife is based on a large, almost helmet-like piece of equipment with multiple sources of radiation in that helmet, all pointed toward the center, all pointed toward the target, which is usually the tumor inside the brain. Now, the linear accelerator system that you see on the left is a little bit different in that you have a large linear accelerator that actually rotates around the patient’s head and provides intersecting arcs of radiation, again all centered at the area of the target, the tumor. If you look very carefully at the two drawings, you can see that they both have rings around the patient’s head. Those are the older form of metal head ring that actually has to be attached to the patient’s head and, in turn, that metal head ring is attached to the treatment couch for both of those older systems, so the big advantage to the CyberKnife is that we’ve eliminated the head ring and we’ll talk more about that in a minute. So both of these older systems are head ring-based forms of stereotactic radiosurgery.

What we had with our older system, from 1995 to 2004, you can see on the slide, are intersecting arcs of radiation, all centered in the target. In this case, it’s a representation of an acoustic neuroma in blue that you can see nestled against other structures within the brain, so this is our older system. Since 1995, from 1995 to 2004, we treated 243 patients and 316 targets. The difference in the number is because some of these patients had multiple tumors that we treated. You can see the diagnoses I that 9-year period of time. We treated a lot of patients with metastatic tumors and a lot of patients with a tumor of the brain called glioblastoma, which is a malignant tumor of the brain itself, what we call a primary brain tumor. We also treated acoustic neuromas, which are benign tumors that are located near the brain stem in the brain, and also treated benign tumors called meningiomas. We treated lymphomas and then a smaller number of other sorts of tumors. You can see, again, the older system. We treated mostly patients with lung metastases and patients with breast metastases. So the take-home message here is that we’ve really been treating patients with stereotactic radiosurgery here at Overlook since 1995, but the CyberKnife is our new advance that we introduced to Overlook in July 2004 and now we’ll go over a couple of slides to illustrate to you why the CyberKnife is so important and represents such an advance in technology.

You can see here on the slide the problems with our older system and with other forms of radiosurgery, such as gamma knife, is that it has a head ring. You can see in this picture that the metal head ring is actually attached to the patient’s head through four pin sites, two pins in the front and two pins in the back. You have to certainly numb the skin before you put those pins in and once the skin is numbed, the patients tolerate the ring quite well, but on the other hand, that’s painful and of course we, as physicians and surgeons, are looking at minimally invasive techniques that minimize pain and discomfort, so that was a big problem with the head ring. Other problems with the head ring are that fractionation of treatments is difficult. What I mean by that is that once you put that head ring on, you really can only give one fraction of radiation, so you can’t bring the patient back to have multiple doses of radiation. You really can’t talk them into having that head ring put on more than once. The other problem with the head ring is that in the older systems, treatment of extracranial tumors is impossible. What we mean by that is that the only tumors we could treat with the older system were tumors within the brain. Everything above the head ring could be treated, so we couldn’t treat spine, we couldn’t treat tumors in the chest or in the abdomen; we could only treat brain tumors.
So what we were looking for in our new radiosurgical system was more approach angles for more conformal therapy. That is, we wanted to really blanket the tumor in a more effective and accurate way with the radiation and we wanted the better localization method. We wanted specifically to get rid of the head ring. We wanted to treat larger tumors because the older systems only allow us to treat relatively small tumors. We wanted to treat extracranial tumors; that is, tumors outside of the brain. In addition to that, we wanted to fractionate the therapy so that if we wanted to give more than one dose of the focused radiation, then we could do that. The older systems didn't allow us to do that. So CyberKnife does all of this and more, as we'll see in a few minutes.

Here is our new CyberKnife. You can see that what we're dealing with is an industrial strength linear accelerator, which is the square box on the end of the arm, mounted on a robotic arm, a robotic arm that actually was made in Germany and is manufactured to provide spot welds on cars, BMWs and Mercedes in Germany, so the accuracy of the robotic arm is very precise and the linear accelerator is mounted on the end of that robotic arm. You can see the couch where the patient lies down and we'll go into more details about that as we go along in the webcast.

With any new technology, it's all about a team. Especially with a new, highly technical piece of equipment, you need a dedicated team that spends a lot of time in training to get up to speed on the equipment. The good thing about our program is that we've really been treating patients with radiosurgery for 10 years, so this is not new technology to us, but the CyberKnife is the new advance, the new advance in stereotactic radiosurgery. Lou Schwartz is the radiation oncologist that you just met a couple of minutes ago. He's the co-director of the radiosurgery program. I'm Brian Beyerl. I'm the neurosurgeon and co-director of the radiosurgery program. Then we also have other radiation oncologists from other institutions and other neurosurgeons, general surgeons, thoracic surgeons, urologists, radiologists, oncologists, and probably the most important people on the team in terms of keeping the program going are the physicists and the technicians, so we have a lot of respect for them because they really know the nuts and bolts of the equipment.

So let's go through CyberKnife treatment, five easy steps. The first step is a patient consult. The key that we try to emphasize in a patient consult is to have both the neurosurgeon and the radiation oncologist see the patient. We think that's the strength of any good program, that what they're really getting is the benefit of both of our expertise to decide the best course of therapy for them, so we actually have patients that are sometimes introduced to our program for consultation that really are not good candidates for stereotactic radiosurgery. If you have both the surgeon and the radiation oncologist giving an expert opinion, then they really get the benefit of both a surgical perspective as well as the radiation perspective. We try to provide that at one visit, if at all possible, here at Overlook, for the convenience of the patient. The second part is that of patient prep. If we're dealing with cranial tumors, then we have a face mask that's fabricated that you can see in the second picture, a fairly tight-fitting face mask, but the patient can breathe very easily through the face mask and it's designed to prevent gross movements of the head during the treatment. At the same time, we obtain diagnostic studies as well. Now, there's a little bit of a difference here if we treat a patient with a spine tumor, such as the patient that we're treating today. The equipment, the CyberKnife, needs a way of tracking movement and correcting for movement during the actual therapy. So for a spine tumor, what we actually do is to surgically implant what are called fiducials in the spine. Now, fiducials are very small stainless steel screws that are introduced and screwed into the spine above, at, and below the area of the spine tumor. The equipment, The CyberKnife equipment, tracks movement of those fiducials during the procedure and, in turn, corrects for movement to provide the pinpoint radiation to the correct location during the procedure. Now, that is a surgical procedure and this patient had that done. It's a day procedure. It's done under intravenous sedation with local anesthesia, so the patient does not have to have general anesthesia. It's considered a minor procedure. I don't minimize any operation, but the patient really tolerates it quite well and there are just small little stab incisions in the skin. We put 5-6 of these very small stainless steel screws in and around the tumor and that provides the CyberKnife with a way of tracking movement and correcting for movement before the pinpoint radiation is given. So we've gone over #3, the image acquisition.

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Then treatment planning is performed and that involves collaboration between myself, the surgeon, and the radiation oncologist, Dr. Schwartz. We basically tell the computer where to aim the CyberKnife so that we outline both the target, as well as surrounding what we call critical structures. There are various structures, for example, in the brain, that we want to minimize radiation to, so if we outline those critical structures, then the computer has a way of, in conjunction with our instructions, planning the radiation to avoid subjecting those areas to radiation.

Then the last is treatment delivery, that we'll go over in a minute because our patient is currently receiving treatment. Since July of 2004, I personally have treated 37 patients, but we've treated almost 150 patients with the unit and my personal patients include six spine metastases, 13 brain metastases, a patient with recurrent glioblastoma—many patients. That is the primary malignant tumor of the brain. I've also treated acoustic schwannomas and trigeminal schwannomas. Those are benign tumors of cranial nerves, which are nerves coming from the brain stem. I have also treated two patients with benign meningiomas and two with central nervous system lymphoma and one with radiation-induced sarcoma. I have also treated two patients with arteriovenous malformations, which are tangles of blood vessels that are congenital lesions. Patients are born with them and they present, unfortunately, with evidence of bleeding, so those need to be treated to obliterate the arteriovenous malformation to prevent them from bleeding again. Just briefly, to give you some case studies, to give you a sense of some of the patients we've treated, this is a patient, a 37-year-old female, who had a low grade astrocytoma, which is, again, a primary tumor of the brain. We operated on her a second time and we gave her CyberKnife to the area. You can see the two left slides show a white area of recurrent tumor and we treated that recurrent tumor with CyberKnife. You can see on the right hand side the response to the CyberKnife, with definite improvement in the area of enhancement.

This may not show up quite as well, a 60-year-old male diagnosed with melanoma. You can see the white spot in the middle of the brain with surrounding swelling. This patient was treated also with CyberKnife. We've treated many patients with brain metastases. You can see here a patient with multiple brain metastases from lung cancer. She has had surgery on one of them and has recurrences in multiple areas that received CyberKnife radiosurgery.

We don't only treat patients with tumors. We also treat patients with a condition called trigeminal neuralgia, which is a form of facial pain, also called tic douloureux, and that is a lancinating facial pain. We treat that by exposing the cranial nerve, the 5th cranial nerve, that deals with facial sensation, with pinpoint radiation. It's very effective to treat the facial pain. Here is a case of arteriovenous malformation. You can see on the left hand side this tangle of blood vessels up near the top of the slide, a congenital lesion that this female was born with. We gave focused radiation to this area after my partner, Dr. Ronald Benitez, who is a vascular neurosurgeon, actually embolized this lesion. So you can tell that the new technology in medicine is advancing very rapidly and we really end up with a multi-modality approach to treating these patients. In this patient, she was embolized by my partner, Dr. Benitez, to decrease the blood flow in the arteriovenous malformation, and then treated with stereotactic radiosurgery.

This is a patient with a spine tumor. We will go over that in more detail in the patient that's being treated right now. You can see in the middle of the slide, the bony body is different in appearance from the surrounding bony bodies and the tumor actually encroaches into the spinal canal, so we treated her with focused radiation as well. In the past, we really could only treat spinal tumors with scattered forms of what is called external beam radiation, which exposed the spinal cord to significant doses of radiation. Now, with the new form of technology, the CyberKnife, for the first time we can treat spinal tumors in a very, very pinpoint, accurate way to really minimize the exposure of the spinal cord to radiation and treat only the tumor.

A patient with a small, you can see right here, small tumor called an acoustic neuroma, a benign slow-growing tumor. This is the brain stem. The brain stem is here. We provided pinpoint radiation to the tumor in this area. So we'll end up this introduction by just summarizing that we can treat with the CyberKnife in any region of the
body, not just the skull, and some technical points about the CyberKnife indicates that it’s very accurate in terms of treating these tumors and other conditions. We can fractionate so we can give multiple doses. We couldn’t do that before. That makes the procedure safer in terms of exposure to critical structures. No need for the invasive head frame. We are very fortunate to not having to subject the patients to having that head frame placed on anymore. At the time of this slide, we were the only CyberKnife unit north of Baltimore and east of Pittsburgh. There are new CyberKnifes coming in all the time, including in our general area, the northeast, but we were the first CyberKnife in the northeast. So that’s an overview and I invite people to email us questions.

LOUIS SCHWARTZ, MD: As we’re sitting here, I’m sure you’re viewing our patient and you can see our treatment is painless. The patient is actually dressed. The patient does not have to undress for a radiosurgery procedure. What I’d like to stress to you is the team approach that Dr. Beyerl alluded to. When you come to the Overlook CyberKnife Center, you will not only see a radiation oncologist, but you will see a surgeon who is appropriate for the part of the body that we want to treat the tumor in. Again, what we want to do is make sure that radiation is the appropriate treatment for you, that you are not a surgical candidate. We also want to take advantage of the surgeons’ expertise as to the anatomy in a particular area. Since we are giving high doses of radiation, we want to make sure that we can avoid the critical structures. The beauty of CyberKnife is that we have the ability to give high doses of radiation. We know that there is nothing that is resistant to radiation. The problem is to get in a high enough dose, yet spare the normal surrounding tissue. There are certain tumors, called melanomas, kidney cancers, that were thought to be resistant to radiation. Well, they did not do well with standard low dose radiation, but when we began giving high doses of radiation with the CyberKnife or before that with other radiosurgery devices, we saw, in fact, they would respond to radiation, so the ability to give this pinpoint treatment gives a dramatic effect on the tumors.

BRIAN BEYERL, MD: We have some email questions that we can answer and give you a sense of an overview here. The first question is what is the criteria for determining if I’m a CyberKnife candidate? Our key here, in terms of the spine, is to expose as many patients as we can to the procedure because, especially in terms of spine tumors, the key for this patient and perhaps for others is that even if you’ve received standard forms of what we call external beam radiation, the older form of radiation, you are not necessarily excluded from being a candidate for CyberKnife, so that’s something that’s important to emphasize, that even if you’ve had radiation to the spine, then you could potentially be a candidate for the radiosurgery, for CyberKnife. As far as criteria for brain tumors, there are other conditions. It’s a very individual sort of question and depends on the patient’s presenting symptoms and their scans. In patients that have metastatic brain tumors, you can’t lose sight of the patient’s overall prognosis. Cancer is a tough, tough problem. Patients sometimes have many tumors in their brain and are not good candidates for the CyberKnife. It also has to do with systemic disease as well. Again, the tough battle of cancer is trying to keep systemic cancer at bay and that also plays into whether the patient’s a candidate for a stereotactic radiosurgery. For primary tumors of the brain, it depends on whether they’ve had previous surgery and often it depends on whether they’ve had a tissue diagnosis. The key here is having tissue diagnosis to know what we’re treating in terms of a pathologic diagnosis, so those are some of the issues that we use in determining criteria.

LOUIS SCHWARTZ, MD: We have another question here. What size tumors can be treated with the CyberKnife? Well, the CyberKnife can only be used on small tumors. Basically a golf ball is about the maximum size that can be treated with our machine. This is because we have to focus multiple beams of radiation on the tumor. If a tumor is too large, we can’t aim these multiple beams without overlapping them. Our goal is not to overlap them. So tumors must be small. When patients come to us, often we see that the tumor is too large and then we have to think of alternatives for the treatment.

BRIAN BEYERL, MD: Part of that, too, plays into the importance of having both a surgical opinion as well as a radiation oncologist’s opinion into the patient’s care. If the tumor is too large for stereotactic radiosurgery, sometimes they’re good candidates for surgical excision. Again, it depends on the patient.
LOUIS SCHWARTZ, MD: What we’re doing right now in the treatment room, we have different sized beams that we can use for treating the patient and when we did our treatment plan, this patient has several different beam or columnator size, so we’re currently changing from one columnator size to another.

BRIAN BEYERL, MD: She’s quite comfortable, as you can see on the camera, tolerating the procedure quite well.

LOUIS SCHWARTZ, MD: We have some more questions here. The first question is does this tumor work on lesions of the spine which were spread from a granulosa cell ovarian tumor? Well, the radiation, as I alluded, will work on any type of tumor, as long as we can give an adequate dose, so be it from an ovarian tumor or any other source, we just would have to review it as a team to make sure it was of a size and in a location that would be amenable to the CyberKnife.

BRIAN BEYERL, MD: We have another question. Can CyberKnife be used for a lytic expansile lesion of the left petrous apex with bony destruction of the adjacent posterior wall of the left carotid canal? This lesion is nonspecific, but considerations include cholesterol granuloma. The size of the tumor is 2x2 cm and it’s thought to be an expansile lytic lesion. Again, the key here is to review the scan and get a sense of whether a tissue diagnosis needs to be obtained to evaluate the patient, but my answer would be that this could potentially be a lesion that could be treated with stereotactic radiosurgery. It would depend on the circumstances and consultation. The good thing in this particular location, the location this patient is talking about is right next to the brain stem. The brain stem is really the crucial part of the brain that deals with life functions itself—things like blood pressure control, heart rate, breathing. In this case, this particular lesion is located in the skull base, right next to the brain stem, so the beauty of CyberKnife and of stereotactic radiosurgery is that we can limit the radiation just to the area of the lesion and minimize the exposure of the brain stem to radiation. So this would be something that could be reviewed in a consultation and could potentially be a candidate.

LOUIS SCHWARTZ, MD: At this time, we’d like to show you a video that reviews the actual patient treatment process for CyberKnife treatment to the spine.

VIDEO: CYBERKNIFE RADIOSURGERY SPINE TREATMENT
VIDEO NARRATOR: Welcome to the CyberKnife patient information video. This program is intended to help you understand the process of undergoing CyberKnife radiosurgery for spine and spinal cord lesions. We believe the more you know about the steps involved in CyberKnife treatment, the more comfortable you will feel throughout the procedure. Overlook Hospital, a member of Atlantic Health System, is the first center in the New York City Region and one of a very select group of hospitals worldwide to offer the CyberKnife for the treatment of tumors and lesions anywhere in the body, including many lesions considered inoperable or otherwise untreatable. The CyberKnife system is one of the most advanced stereotactic radiosurgery systems available. It uses image-guided robotics to attack spinal tumors and other lesions with multiple beams of extremely accurate radiation.

VIDEO: STEVEN CHANG, MD: The CyberKnife was developed, in part, to overcome some of the restrictions of conventional radiosurgical devices. One of those restrictions was the ability to treat only cranial lesions. Now we can treat tumors throughout the entire spine and throughout the entire body, for that matter.

VIDEO: WENDY DUNHAM, CYBERKNIFE PATIENT: I had a doctor in Dallas say, yeah, I could perform surgery and we can get the AVM out, but you’ll be in a wheelchair. I’m like, well, that’s not an option. I’m not going to do that. So when we found CyberKnife as another alternative, that was just kind of a dream come true because there wasn’t any other option for me.

VIDEO NARRATOR: Through its combination of robotics, real time imaging, and extremely accurate beam delivery, the CyberKnife system represents a major technological advance in radiosurgical treatment. The CyberKnife system is used to treat a variety of lesions located in the spine and spinal cord, including malignant tumors, such as spinal metastases from many sources, myelomas and lymphomas; benign tumors, such as meningiomas, neurofibromas, and Schwannomas; vascular malformations, such as arteriovenous malformations; and other conditions as determined by your doctor. During your initial consultation, your doctor will carefully
review your case to determine if CyberKnife radiosurgery is a potential treatment option for you. CyberKnife treatment involves a team approach and several specialists may be involved in your treatment. Your team might include a neurosurgeon or orthopedic surgeon, radiation oncologist, medical physicist, radiation therapist, or other medical personnel.

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VIDEO: LOUIS SCHWARTZ, MD: As a radiation oncologist, my role in the team is to help to decide proper ways of delivering the radiation and making sure that the doses, the critical structures, are within tolerance levels. I do this in conjunction with the various surgeons that we'll be working with and their input is mainly to tell us what the critical anatomy is; in other words, where the tumor is precisely located, where critical structures that we want to avoid from high doses of radiation are located, so again, we're a team working together.

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VIDEO NARRATOR: The following steps are typical for CyberKnife treatment of spine and spinal cord lesions. The outpatient CyberKnife procedure consists of four main steps:

1. Fiducial implantation.
2. Setup and imaging.
3. Treatment planning.
4. Treatment.
Follow-up.

These steps are generally performed on an outpatient basis and are spread over several days. While it's important that you understand these steps, it's more important that you carefully follow the procedural guidelines established by your treatment center. You will first be scheduled for a short outpatient surgical procedure to implant tiny metal markers called fiducials into the spine bones near your lesion. The CyberKnife system uses the fiducials as reference points for precisely targeting radiation to the lesion.

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VIDEO: MICHAEL WANG, MD: Prior to the actual treatment with the CyberKnife, fiducials have to be placed under the spinal column itself. This involves, in a minimally invasive fashion, putting 3-6 small gold screws into the bone on the spinal column itself. This allows for accurate targeting and localization by the CyberKnife robot so that the tumor can be actively and selectively ablated while sparing the critical nerve tissues.

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VIDEO NARRATOR: Fiducials are typically implanted under local anesthesia in an operating room or radiology suite by a surgeon or interventional radiologist. In some cases, general anesthesia is used. 4-6 markers, each 3-4 mm long, are implanted into the vertebrae through small skin punctures. There is minimal pain associated with this procedure. The fiducials are harmless and do not need to be removed after radiosurgery treatment. Following fiducial implantation, you will return for setup and imaging. First, a custom body cradle for thoracic and lumbar spine lesions is created to help keep your body properly positioned during treatment. The cradle is made from a soft material that molds to your body. For upper cervical spine lesions, a custom mesh face mask will be made instead. The face mask and cradle are painless and noninvasive. While fitted with the body cradle or face mask, you will undergo a CT scan. An injection of contrast dye may be given intravenously to better visualize your tumor or lesion. The CT data will be used by the CyberKnife team to determine the exact size, shape, and location of your tumor or lesions. An MRI scan or other imaging study may also be needed to fully visualize the tumor and nearby anatomy. The treatment planning step is next performed by a medical physicist in conjunction with your doctors. You will not be present during this step. Your CT and MRI information will be downloaded into the CyberKnife system’s treatment planning computer and used to develop a customized treatment plan. The medical team will outline the target volume on the computer, input the optimal dose to the target, and identify nearby critical structures where radiation should be minimized. The CyberKnife system’s computer then performs millions of calculations to generate the optimal radiation delivery plan for your lesion. Your treatment plan will take full advantage of the CyberKnife systems high maneuverability, allowing a more accurate and even delivery of radiation. After the treatment plan is completed, you will return to your CyberKnife center for treatment. Your doctors may choose to deliver the treatment in one session or stage it over several days, typically no more than five days. Occasionally, more than five treatments may be required. Dress comfortably for your treatment. Remember, you'll be lying in the same position for up to 90 minutes. You may want to bring something to read or listen to while waiting for treatment. If you usually have pain while laying on your back, your doctor may instruct you to take pain medication prior to treatment. You will be escorted into the treatment room and fitted with your
body cradle or face mask. Your center may allow you to bring a music CD to listen to during treatment. The room will be cleared to protect the treatment team from x-ray exposure; however, you will be monitored through closed circuit television and will be able to communicate with your treatment team at all times. Digital pictures are acquired by the CyberKnife’s imaging system to establish the target location. The computer-controlled robot will slowly move the radiation source, or linear accelerator, to multiple positions around you as you lie on the table. At each position, the robot will stop and fire a beam of radiation at your tumor or lesion. If you move slightly, the change is detected by the imaging system, which automatically adjusts the robotic arm before firing the radiation beam. Each beam is thus accurately targeted to the lesion throughout the treatment. A typical treatment consists of 100-150 beams. You needn’t do anything during the treatment except lie as still as possible. Treatment sessions usually last 30-90 minutes.

VIDEO: DON RESCHKE, CYBERKNIFE PATIENT: You lay down and you lay there, still, for 45 minutes. You have some great music in the background and there’s no pain to it. It’s like going to a dentist’s office when they do a little x-ray on your teeth. It’s the same thing. You don’t feel anything. So just getting up and going back to work was easy.

VIDEO NARRATOR: You can usually go home immediately upon completion of treatment and resume your normal routine. If your treatment is being staged, you will return for additional treatments on separate consecutive days or as determined by your doctor. Generally, there are minimal side effects from CyberKnife treatment.

VIDEO: IRIS GIBBS, MD: CyberKnife radiosurgery, just like any other form of radiosurgery, may have some acute side effects.

VIDEO NARRATOR: There may be side effects, such as mild, temporary nausea, especially if the treated target is in your lower abdomen area. Your doctor may prescribe medication to control any side effects, should they occur. It’s very important to schedule and attend follow-up appointments with your doctor upon completion of CyberKnife radiosurgery. Keep in mind that your tumor or lesion will not suddenly disappear after treatment; it may be several months or longer before the effectiveness of your CyberKnife treatment can be determined. By routinely evaluating your symptoms and following your postoperative MRIs, your doctor can determine your post-treatment progress.

VIDEO: WENDY DUNHAM, CYBERKNIFE PATIENT: I’m just excited to haveÖI can’t believe I’m saying this. I’m excited to have an MRI every single year to find out how much it has shrunk and to know that this was all worth it. And I’m just so happy that I did it, and I just had radiation yesterday. I had radiation the last three days in a row and I feel fine. I feel fine. And my outlook is good. I mean, I’m excited about it.

VIDEO NARRATOR: The CyberKnife system represents an entirely new approach to stereotactic radiosurgery. By eliminating the frame, it allows patients with lesions in the spine and throughout the body to benefit from the advantages of radiotherapy. Best of all, the CyberKnife system provides new hope for patients with inoperable or otherwise untreatable conditions.

VIDEO: BRIAN BEYERL, MD: The new technology aspect of CyberKnife, I think, in and of itself, can be encouraging to the patient.

VIDEO: JOHN ADLER JR, MD: CyberKnife radiosurgery, because it is so precise and so effective, in many ways represents a revolution in surgery.

END OF VIDEO

BRIAN BEYERL, MD: I just wanted to emphasize one point about the follow-up. Follow-up is key. Usually what happens is that the coordination of the CyberKnife, in terms of planning, is done through the surgeon’s office and I take great responsibility in doing everything I can to follow the patients very closely after the CyberKnife treatment. We’ve had patients that we’ve treated as far away as Chile. Obviously we can’t follow the patients
from a great distance, so we need to do everything we can to make sure that local oncologists and local physicians follow the patient very closely with repeat scans and follow-up.

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LOUIS SCHWARTZ, MD: We have another question here. The question is what is the difference between CyberKnife and Trilogy Accelerator System extracranial radiosurgery? Well, the Trilogy is another device to deliver pinpoint radiation. The main difference between the CyberKnife and these other systems is that with the CyberKnife we actually monitor the positioning of the patient while they're getting the treatment. With all other systems, the patient is set up to best accuracy and then the treatment is delivered, but as you can see on the screen, during the treatment we are taking films and the computers are analyzing the position of the patient to make sure we're right on target so that adjustments can be made. Patients can lay as still as possible, but in spite of their efforts, there can be minimal movements which could interfere with the targeting and that is the main advantage of the CyberKnife over all of these other systems, the precision, the changing of the patient's position if there is any movement while they’re actually getting their therapy.

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BRIAN BEYERL, MD: So even before any pencil beam of radiation is given, every time a pencil beam of radiation is given, the patient's position is checked, the computer makes sure the patient hasn't moved, and corrects for that movement before giving the radiation.

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Let’s go on to answer another email. Why do I have to have a consultation with two physicians? I mentioned that before, but it’s important to emphasize. The patient really needs the expertise of both a surgeon and the radiation oncologist. In these days of high specialization in medicine, the patient really needs to have a surgical perspective and a radiation perspective. It’s a complement between the two perspectives. There are patients that are seen in consultation that are excellent candidates for CyberKnife radiosurgery, but actually they may be candidates for other forms of radiation or they may be candidates for surgical procedures to surgically excise the tumors, so we always try to look at the entire picture and try to decide the best approach for each individual patient.

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LOUIS SCHWARTZ, MD: I’d like to mention at this time some other features of the CyberKnife system. Right now we're treating a spine, which is a relatively thick structure, but we have to treat other areas of the body, such as the lung. When we have a tumor in our lung, the lung will move with breathing and the tumor will move. The CyberKnife has the ability to track the movement of the tumor with breathing, so literally the CyberKnife will breathe with the patient. This enables us to continue pinpoint treatment in spite of the movement of the tumor.

With standard radiation systems, you have to treat a larger volume to ensure you’re fully covering the tumor as it moves with each breath.

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We have another question here. People are asking how many patients have we treated? We’ve treated approximately 150 patients at the Overlook CyberKnife unit. The great majority have been for neurological purposes to the brain and spine, but we have treated several lung patients and pancreas patients. We are planning to expand to treating prostate patients. The system has advantages for treating tumors anyplace within the body, but again, they must be small tumors. We cannot treat large tumors.

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BRIAN BEYERL, MD: Another email question: How do the patients feel after the CyberKnife treatment? The patients feel fine. They may have slight degrees of fatigue after the radiosurgery, but they frequently drive themselves to the program, get their treatment, and drive themselves home. If they do feel some fatigue, then it usually resolves in a day or two. Many of these conditions need pre-treatment with medications before they get CyberKnife radiosurgery. Brain tumors are one in particular. If the patient has a brain tumor, then often we pre-treat them with a medication called Decadron, which is an anti-swelling medication to prepare them for the radiosurgery. Patients have minimal side effects from those medications, usually, and the medications are often tapered relatively quickly after the CyberKnife, so they feel quite good.

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LOUIS SCHWARTZ, MD: The next question is does the CyberKnife completely get rid of the tumor? Well, we wish we could say that the CyberKnife was 100% guaranteed that your malignancy or even benign tumor will be controlled or cured. However, as with all things in life, the CyberKnife is only effective to a certain degree. We try
to stop the growth or shrink tumors, but sometimes in spite of the CyberKnife, the tumor will continue to grow, so we still do not have a complete answer, but we have something that's quite good. Now, as far as getting rid of the tumor, we're not necessarily looking for disappearance of the tumor. What we'd like to do is stop the growth of the tumor. Often that is the result that we see with the CyberKnife and we're quite pleased with it. In other words, on subsequent scanning we see that the tumor has not changed in size and that is a good result.

BRIAN BEYERL, MD: That also depends on what type of tumor we're treating. There are some patients that have metastatic tumors of the brain, for example, that we see quite dramatic shrinkage of the tumors after CyberKnife radiosurgery. We've even had patients where the metastatic tumors disappear on subsequent scans after CyberKnife radiosurgery, but as Dr. Schwartz said, no form of radiation, including CyberKnife, should be considered a cure for cancer. The response of other kinds of tumors is often predictable. For example, if we have a benign meningioma, a slow-growing, benign tumor of the coverings around the brain, then we know after CyberKnife radiosurgery that the tumor usually does not shrink in size, so if we can arrest the growth of the tumor so that on follow-up subsequent scans the tumor hasn't changed in size, that's a good result, as far as we're concerned. The same goes for an acoustic neuroma and sometimes, as I mentioned before, there are other conditions or lesions of the brain that we follow in different ways. For example, patients that have trigeminal neuralgia, if we treat the cranial nerve with focused radiation to help their facial pain, then they don't need subsequent follow-up scans. In the case of arteriovenous malformations, the congenital tangle of blood vessels in the brain, sometimes they don't get scans; they actually get arteriograms of the brain, where contract dye is injected in the arteries of the brain to see if the arteriovenous malformation still fills. Sometimes we wait as long as a year after the CyberKnife radiosurgery to repeat that arteriogram. So the follow-up, as I said earlier, is very important and can vary, depending on the patient and on the condition that we're treating with the CyberKnife.

LOUIS SCHWARTZ, MD: Our patient today is receiving the third of three treatments that we're delivering to her spine. We divide the CyberKnife treatments up between 1 and 5 treatments. Five is the maximum that we will deliver. What determines how many treatments we deliver the therapy in is the proximity to a critical structure. The CyberKnife is a focused treatment; however, there is still some radiation that will go to the critical structure that sits adjacent to our target. Because of that, we sometimes divide the treatment up. In this particular case, we're treating the vertebral body that sits right around the spinal cord. Even though the full dose of radiation is being delivered to the vertebrae, there is still some radiation delivered to the spinal cord. For that reason, we chose to divide it up over three treatments to try to limit the exposure to the spinal cord. We run into this problem sometimes within the brain. If a tumor is located near the nerve that control vision, the optic nerves, sometimes we will divide the treatment up to limit the exposure of those structures. What the therapists are looking at on the screen that we were just showing, they're actually looking at the fiducials that Dr. Beyerl implanted. That's what the computers look at. They do not look at the tumor itself. They look at those fiducials, those tiny screws that were placed in, and they know where the tumor is located relative to those fiducials. The imaging devices on the CyberKnife are constantly looking at those fiducials to make sure they're in the right position. That's how it knows that we're on target. I don't know if you can visualize this, but this particular patient has six fiducials that were placed in and we're monitoring them for positioning.

BRIAN BEYERL, MD: I should say, too, that other kinds of tumors, for example in the chest, lung tumors, that kind of thing, intra-abdominal tumors require fiducials as well. The fiducials, in the case of thoracic and abdominal tumors, are actually in the form of what are called gold seeds. They're very, very small metal seeds that are surgically implanted in and around the tumor, as opposed to the small stainless steel screws that are used for spine tumors, so with all tumors at this point outside of the brain or upper cervical spine, those fiducials need to be placed surgically. Again, the patients tolerate it quite well and it's used to follow the movement during the procedure.

LOUIS SCHWARTZ, MD: Right now our patient has completed her treatment and she's smiling, getting ready to get up. There's no pain or discomfort associated with the treatment. The only discomfort is that she's been lying still for almost an hour, so that's the only discomfort that the patient notices, but you're going to see she's going to get up and walk right out of the room.
BRIAN BEYERL, MD: I’m always impressed with patients that battle cancer in this way. This patient, in particular, has a wonderful attitude and that’s hard to maintain in these long treatments. I always use the analogy of cancer being an endurance race, rather than a sprint. This patient has a wonderful attitude, always has a positive attitude, and she’s been battling this for a long time. She’s a brave lady and we thank her very much.

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LOUIS SCHWARTZ, MD: We have one other email question here. Why get CyberKnife, opposed to other treatments? Well, it depends what we’re dealing with. If we’re dealing with a small tumor that cannot be removed surgically, that is a patient who is a good candidate for consideration for CyberKnife. A patient who has had prior radiation and has a recurrence of their tumor in an area that has been previously radiated, that is a patient that can be a suitable candidate.

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BRIAN BEYERL, MD: We want to emphasize if you are a patient that would like a consultation in the Overlook CyberKnife program to see if you are, in fact, a CyberKnife candidate, we would ask that you contact the CyberKnife coordinator. The phone number is (908) 522-5624. As a closing thought, I want to thank the entire CyberKnife team here at Overlook Hospital and Atlantic Health, as well, for supporting our program. It’s an exciting new form of technology. Technology is an amazing thing, especially in medicine, as it advances and is able to treat more and more types of, in this case, tumors, but we really pride ourselves on this program to not lose the human touch. You really need to be empathetic with the patients, you need to follow them closely, and we pride ourselves on having that kind of program. It’s more than technology; it’s all about compassion and following the patients closely after the treatment. As I said, we pride ourselves on that follow-up.

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LOUIS SCHWARTZ, MD: Thank you for joining us today. We hope we can offer this revolutionary treatment to many of the people in our area. Thank you.

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BRIAN BEYERL, MD: Thank you very much.

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NARRATOR: Thank you for watching the live, revolutionary CyberKnife stereotactic radiosurgery on the thoracic spine, from Overlook Hospital in Summit, New Jersey. To obtain more information, to make an appointment, or to receive a physician referral, please click the buttons on the screen.