HEATH SKINNER: Hello, everyone and thank you for joining me to learn a little bit about how we use radiation to treat cancer. By way of introduction, my name is Heath Skinner. I'm the Chair of Radiation Oncology at the University of Pittsburgh and the UPMC Hillman Cancer Center. So thank you for joining me. And I have no disclosures to declare.

So first let's talk a little bit about radiation globally. Now you may or may not know, but radiation is used to treat approximately half of all cancers. Which is to say about half of cancer patients will receive radiation during the course of their illness. In addition, now some of that is obviously palliative, but additionally approximately 40% of all cancer patients will have radiation as a part of their curative treatment, at least for solid tumors.

Now, as you may or may not know there's lots of different ways to treat with radiation. And each has their pros and cons. And we're going to talk about some of them today. But the most important take home I want you to take away from this discussion is that each patient needs a multidisciplinary personalized treatment plan delivered and generated by experienced professionals.

Patients need radiation oncologists, surgeons, medical oncologists, radiologists, pathologists at the table and engaged. And I'm proud to say that we do that within our own network at UPMC. So let's talk a little bit about broadly speaking, what are the radiation types?

And I'm going to divide this talk into three broad categories, external beam radiation, stereotactic radiation, and brachytherapy. And we'll talk about the most common thing being common, which is external beam radiation.

This is generally speaking, what you're going to see in your practices, what the bread and butter of radiation oncology is. External beam radiation, it means it's radiation that comes from a machine outside the body to the area that we want to treat. It can be delivered using a linear accelerator or a proton therapy unit or some other more esoteric things. But that's generally how the external beam radiation is delivered.

That's delivered over the span of multiple days. Typically speaking, it's Monday through Friday, at least in the case of outpatient medicine. Sometimes for inpatients we'll be treating on the weekends as well. Radiation delivery has changed dramatically, even over the past five to 10 years.

Indeed, some patients are treated in as little as five treatments, even with external beam radiation, not stereotactic radiation. We're going to get to that. But even with external beam radiation. Moreover the toxicity has dramatically reduced in almost all instances due to a few things, changes in technique, the way we do things, and changes in the area that we treat.

And a lot of that is keyed into improved systemic therapy, allowing us to shrink our fields. And just as an example, you can see here in the figure how lymphoma treatment for example, has evolved over the decades. 1960s and '70s, this big mantle field, bilateral necks, axilla, mediastinum, abdominal chain, all the way down into the [INAUDIBLE]. But over time, you can see that the areas in blue that we were treating with radiation reduced.

And why? Systemic therapy improved. Our outcomes data became more mature. We figured out how much radiation that we needed to give.

And you can see that not only did the fields reduce to now we're treating involved node in many instances as you can see on that the extreme side of the figure, but we've also reduced our doses. And I will throw out here that sometimes we'll be looking at secondary malignancy data, and you'll see an increase in patients that were treated, let's say in the 1980s or 1990s. But you can see here how much of a difference we actually have had over the span of those decades.

Obviously, with larger areas that we're treating with radiation, you're going to see more secondary toxicities. If patient's particular area sees radiation, it's going to be at risk for toxicity. But if it doesn't, it doesn't. So we can see that even in that instance, over that span of time, we've dramatically reduced our dose and our volume, which reduces our secondary toxicities.

Moreover, we figure out other ways to utilize technology to improve the way that we treat with radiation. And here's just a couple of examples. So any time we treat with radiation, we have to do a planning session. So what is that? It's a CAT scan. It's a glorified CAT scan in many instances.

But what we can do now, looking at the two images of the lungs that you see is that we can generate what's called a breath hold scan. So as opposed to just scanning a lung throughout the entire breathing cycle, we can have the patient hold their breath and we can monitor exactly where that breath hold is, and then evaluate in that setting with the CAT scan, but also treat in that setting. So what does that do?

So that reduces the area that we actually have to treat with radiation. So on the left in the free breathing scan, we would have to treat a volume. And the red is the area that we would have to give some radiation dose to account for a patient set up in motion. And that volume is about 325 cc's.

However, utilizing a breath hold scan as opposed to trying to treat the tumor wherever it is in the breathing cycle, if we hold if the patient holds their breath for a short period of time during the scan and also during the treatment, we can cut that area that we have to treat with radiation by more than half. So that's just one way that we're using technology to, again, improve toxicity.

Additionally, we're doing things like hydrogel injection. So for example, in the screen, you can see basically sagittal cut of the CT. And I outlined in red a little area where we've actually injected hydrogel to push the prostate away from the rectum. So that allows us to isolate the prostate. Because one of the real toxicities that we see with prostate radiotherapy is actually incidental dose to the rectum. But if we can move the rectum out of the way, we can dramatically limit that.

So that's just a few of the ways that we're utilizing technology throughout our network at UPMC to reduce toxicity. So that's one way that works. That's a generalized way of how we're trying to reduce toxicity. Now getting to how we treat with external beam radiation. There's a few key different methods, right?

Each has their pros and cons. But I also put up here, it's like a fight neck, right? Which one is best? And honestly, largely depends upon the setting. And one of the key things that you've probably seen in the literature that I will discuss in this talk is, IMRT or VMAT versus protons. There's been a huge nationwide discussion and it's leaked significantly into the lay press in regards to protons and the state of the art and the latest technology.

But what I'll show you a little bit later on is that that's probably not the case, at least right now based on the data that we have. But regardless, there is a large discussion that's currently ongoing. So I'll start with the easy one, 3D conformal radiation. This is what we've had around almost since the initiation of utilizing radiation to treat human cancer, at least in some capacity or another.

Now the 3D conformal part comes when we're actually using CAT scans to plan the radiation better. But regardless, the same general principle is applied almost since the turn of the 20th century, which tells you how long we've been using radiation to treat human cancer. So what are the pros of 3D conformal radiation? What is it first off?

It's basically one or two or three or four beams that are just the same intensity throughout the beam. They may be different shapes, but they're same intensity throughout the beam, hitting a target or a group of targets. So firstly, they're generally quick to plan and treat.

And honestly, this is the vast majority of what we do when we're trying to palliate a patient. We will generate a relatively quick 3D conformal plan with a few different fields, APPA, front and back, or what we call a four field box, which is AP, PA, and then coming in bilaterally. But regardless, the goal is to palliate the patient, to treat to doses that are helpful for pain control. And again one of the best ways to control pain in a cancer patient in many instances is actually radiation.

So please don't forget that as you see these patients. Please consider giving a call to your local radiation oncologist, because they can potentially really help both with pain as well as a few other specific scenarios for palliation. Moreover, it's cost effective. Three conformal radiation is quite cost effective.

We can usually get this through insurance coverages relatively quickly and easily. There is minimal delay. And indeed a lot of times we're actually doing this either evaluating the patient in the inpatient setting or actually treating as an inpatient.

Finally, even in the definitive or post-operative adjuvant setting, we still utilize 3D conformal radiation for a few key tumor types, for example, breast cancer. 3D conformal radiation oftentimes provides a very nice plan in the adjuvant setting for breast cancer. And indeed, I alluded to earlier that we're moving more toward lower numbers of fractions for patients.

And I had breast cancer in mind for example. We're treating a lot of these patients with just five treatments and be done. We keep the heart out of the field. We keep the lung out of the field. And these patients have very, very, very low levels of toxicity. And we would argue that the toxicity of five treatments of radiation for breast cancer versus years of hormonal therapy, the breast cancer radiation is actually the least toxic aspect of that compartmentalized therapy.

But like many like anything in life, there are both pros and cons to 3D conformal radiation. Generally for example, it is less conformal than other modes of radiation that I'm about to talk about. That's why we've moved more towards IMRT in certain settings, particularly in areas where the anatomy is very complex, for example, in the head and neck region. So that lack of conformality in many instances, can lead to more side effects. So again, in areas where the anatomy is complex, we typically do not use 3D conformal radiation if we're trying to deliver very high doses of radiation.

So let's get to IMRT and VMAT. And this actually forms the bulk of many of our practices as radiation oncologists, at least in the modern era. IMRT/VMAT, what does that mean? Intensity modulated radiation therapy or volumetric art therapy, either way. It's just different ways to, for lack of a better word, make radiation bend. What you can do is not only have multiple different beams of radiation coming in, but each beam is modulated in intensity.

The way I describe it to patients is imagine you had a bicycle wheel. So each spoke is a beam of radiation. And the hub at the center is the area that you want to treat. So you've got all these little beams or beamlets that are all modulated. And we utilize a computer program as well as specialized planners to actually go from what we want to treat and what we want to avoid, plug that into a planning system with the help of specialized planners, and out comes an algorithm that allows us to, again almost bend radiation for lack of a better word.

So again, highly conformal, highly conformal with the doses that we want to treat with. Moreover, there is actually randomized data showing improved toxicity and actually outcomes versus 3D conformal radiation in several different disease sites. And in the modern era, it's actually quite quick.

And indeed in certain instances, although it belies my previous point about palliative radiation, there are some instances, particularly for complex anatomy, I can generate an IMRT plan much more quickly than I can a three conformal plan. I'm going to finally in the modern era, IMRT treatment can be quite rapid. Indeed, sometimes it's even less than five minutes, depending upon the complexity of the plan.

Now what are the downsides of IMRT? Firstly, because radiation has to go somewhere, if we are very conformal with our high doses, there are some areas of the body that will actually receive more low doses of radiation. But what we find is that in most instances most of the time, that's not as clinically significant, at least in regards to toxicity.

Now, IMRT sometimes takes longer to plan than 3D conformal. And that's usually in the setting of relatively simple anatomy for which we're trying to palliate. And finally, insurance approval is sometimes not forthcoming for certain disease sites. And we're working to change that. But there are some disease sites even now where we have to go back and forth with the insurance, potentially generate a comparative plan, 3D versus IMRT. But again, that's even changing in the modern era.

So generally, and again generally, the bulk of our practice is this high tech, modern, IMRT and VMAT radiotherapy. And this is just a picture of what we see when we compare these two modalities. So you can see slices from a CAT scan, axial slices, as well as some coronal cuts, basically showing the areas that are treated with the 3D conformal radiation versus the IMRT or VMAT.

And the bottom line is that green on the left or red on the right is actually the high dose area. And then the red on the left and the green on the right, sorry, for the confusion there, is actually more lower dose radiation. And you can see that the high doses in both are more conformal. And moreover, even particularly on the left, that area of low dose is at-- or low to intermediate dose I should say, is actually less with the IMRT, in least in many instances.

So we really can achieve a much greater degree of conformality, a much smaller area that we treat with a higher dose with the IMRT. So I mentioned randomized data just very briefly. This is a randomized trial of 600 patients with nasopharyngeal cancer, looking at 3D conformal versus IMRT. And the bottom line for this is not only improved toxicity but that actually led to a significant improvement in overall survival.

And you can see in the top row where the total trial of 616 patients you see the overall survival rates were significantly improved with a 1.77 hazard ratio in patients that received straight IMRT, linking directly a toxicity benefit to a survival outcome. Moreover, this is data looking at patients with cervical cancer treated with adjuvant radiation, 3D conformal versus IMRT. And this was just published last year, showing an improvement n greater than or equal to grade 2 GI toxicity in patients treated with IMRT versus 3D conformal. And generally this is what we're doing as well, based upon this data as well as some others.

Now protons, which is again I alluded to earlier, this has been there's been a lot of discussion, both within the radiation oncology community as well as the larger oncology community, as well as even in the lay press about protons. So what are protons? Protons are another form of radiation. They're another form of radiation.

They have specific physical characteristics that have historically made them intriguing for radiation oncologists to look at in that, you shoot them at a target, they go through tissue water or whatever until they reach a certain point based upon their energy. And then they deposit their energy, and then they stop. And that has been really one of the reasons why radiation oncologists and the field in general has been interested in protons for decades. And they are finally now utilized in several centers throughout the United States.

So what are the pros? So similar to IMRT, at least with more modern proton therapy-- historically this wasn't quite as accurate, but with more modern proton therapy, they can be highly conformal, with again a minimal. Now the pro here is that on paper there is a minimal low dose to normal organs. And if you recall previously, IMRT did give some more low dose to normal organs.

And I put it as both a pro and a con. There is mixed randomized data for toxicity versus IMRT. And I'm going to discuss that with you today, because I think it's important, particularly when you look at the cons for proton. Firstly, it's costly. It has historically been costly and many insurance policies don't cover protons, partly because of that mixed randomized data that I alluded to.

There's a few sites nationally. There's several new sites that are being put in. But there's fewer sites nationally. And the final bullet point is potentially less robust. What does that mean? Well, if I take my standard photon based radiation either 3D conformal or IMRT, and I shoot that beam at something, generally speaking, regardless of what I'm shooting it at, I can generally predict how far that radiation is going to go.

I know how far it is. I know generally speaking how much energy it's depositing along that entire path. And it sort of matters, but not really what stuff it's transitioning through. There is some, but not dramatic.

Protons on the other hand, are exquisitely sensitive in regards to what you're shooting it through, whether it be muscle, bone, air, whatever. They're very sensitive. So you can imagine even a small movement of a patient on the table or, what we hope for, which is tumor response, can dramatically change the dose of radiation that the body sees if they're getting protons.

So that's what I mean by less robust. Now there are constantly evolving ways to try to take that into account. But it's still an issue when you're treating with protons. But here is the potential advantages. You can see here on the left, that's a liver tumor that was treated with either IMRT based radiation, where it says photons, or protons.

And you can see there's a lot less low dose. The light blue is low dose radiation. There's a lot less low dose radiation. Moreover on the right, you can see head, neck, same thing. There's a little bit less low dose radiation, particularly in the anterior oral cavity. So that's the hope. That's the potential promise of protons.

But in actuality, it's not really been borne out, at least by most of the randomized data. For example, this is a publication from Anderson back in 2018, where they randomized non-small cell lung cancer patients to protons versus photon based radiotherapy. There was no difference in any of the toxicity or local failure, which were the co-primary endpoints.

And indeed, if you looked just numerically, again not statistically significant, but if you look numerically, the greater than or equal to breakthrough pneumonitis rate was actually higher for protons versus IMRT. Again, not statistically significant, but certainly not in the direction that we would have hoped for. Moreover, this is a more recent trial looking at patients with GBM treated with either protons or photons.

And you can see there's an imbalance here in regards to patients. But regardless at least in regards to the primary endpoint, there was no difference in cognitive decline. And you can see that in the large Kaplan-Meier curve on the left. Now, grade 2 toxicity of IMRT was greater numerically. It didn't quite hit that p value of 0.05, but it was greater numerically.

Flipside is, if you look at the progression free survival, which is the middle Kaplan-Meier curve at the top, numerically at least, progression free survival was actually slightly better in the IMRT arm. But again, that also not statistically significant, that p value of 0.24. So it's hard to make much of that.

Primary endpoint's negative. Potential for toxicity reduction for grade 2, but the progression free survival was in the opposite direction of what we would like to see. So again, challenging to interpret.

Now the one positive clinical trial for protons in any disease site to date is this trial by Steven Lin out of Anderson. It was a Bayesian design. Patients with locally advanced esophageal cancer are treated with upfront chemoradiation. Now, the primary endpoint was total toxicity burden, and this was a Bayesian design. And I'm just going to read to you from the study conclusions.

The posterior probability that the mean TTB was lower for protons compared with IMRT with 0.9989, which exceeded the trials design stopping boundary of 0.9942 at the 67% interim analysis. This is challenging to interpret. Bayesian designs have many things going for them, but for me, it's a little challenging to interpret them, particularly in the context of the fact that if you look at a frequentist based analysis, you saw no difference in progression free survival, no difference in overall survival, and really no difference in any of the toxicity endpoints, with no statistically significant difference in the toxicity endpoints, with the exception of this total toxicity burden.

So again for me, personally challenging to interpret. So, why thus far have we not seen this dramatic benefit for toxicity in regards to protons versus IMRT? I think there are many explanations. And indeed, there are multiple clinical trials currently ongoing to evaluate this further in larger trials.

There's a phase III trial in esophageal tumors. There's a phase III trial in lung tumors. So again, this is certainly an active question. But why haven't we potentially seen this dramatic benefit in all of these drugs?

So one possibility is getting back to that robustness thing a little bit. So generally speaking with photons what you see is what you get. When you do your plan, you look at it, you look at the planning, you look at what is effectively a topographic map. You got your high doses, what I usually like to look at red, and then your intermediate doses, which I usually like to look at green, and your lower doses, which I usually like to look at blue. Generally speaking, what you see is what you get.

Now over the course of therapy, I will adjust that if the patient loses a lot of weight. My primary specialty is head and neck cancer. So the patient loses a lot of weight or the tumor dramatically responds, I will adjust. But even in that setting, the treatment is usually pretty robust. , Again what you see is what you get.

The challenging thing with protons is the thing that makes them potentially beneficial is also something that can make it challenging. It's the characteristics of the beam. So, with protons, you shoot it at something. When it hits bone, when it hits muscle, when it hits soft tissue, that significantly can change the characteristics of the beam.

So again small patient movements, one treatment, small setup errors, small or large changes in tumor and the tumor itself, can actually affect what the plan looks like. So that's one thing. The second thing is that we try to calculate the dose delivered by protons, but it's not the same quite calculation as with what we have the experience with for IMRT for photons. So this is actually a paper that was published relatively recently on the left, looking at different ways to model proton dose. Like the what you see is what you get dose for protons.

And what they found is the panel B was what was thought was given. But panel E is actually using a slightly different model to generate the dose. And what you see is that if you use that slightly different model, you have a much higher dose potentially delivered to that area. Now, why do we think that model may be better?

Well, you see in panel C, the patient after therapy had an ulcer in that area. You wouldn't have expected that based on the dose you thought you were delivering. But based upon panel E, maybe it was a higher dose than what you thought.

Moreover, there's actually a table here of several different studies looking at what we call osteoradionecrosis. Again, I'm a head and neck guy, so I'm focused on that. Osteoradionecrosis is basically, you treat something with radiation, you treat the jawbone especially in head and neck cancer, over time some patients will either have an insult or injury to that area, or will just simply over time develop it, but basically an area that doesn't want to heal. A lot of different things that we can do for it.

We can have some drugs that we can use, maybe even hyperbaric oxygen. But sometimes you actually have to have a surgeon go in, remove the area of diseased bone and reconstruct. And it's not a pleasant thing at all.

So these are all retrospective. These are not randomized trials. But what has been seen historically in probably the largest series was about a 4% to 5% risk of osteoradionecrosis in head and neck cancer patients looked evaluated longitudinally. Now generally speaking, some of the larger series for protons-- well it's a little variable because we don't have that longitudinal data as much. But the larger series today of 122 patients actually had a 10% risk of osteoradionecrosis.

Now again, that's not dispositive. There's another series there where the risk is much smaller. But you know I think it's something to consider. Because unfortunately, with protons sometimes what you see isn't what you get.

So I will be excited to see what the randomized data, the large randomized trials show for protons. But at least at this point, my enthusiasm has waned a little bit based upon the trials that we've had to date. So at present, my standard for my patients is generally speaking, no protons except in the context of a randomized trial. That's generally what I've tried to adhere to in my practice.

Now, getting to another form of radiation, as if it wasn't complicated enough, let's talk about stereotactic radiation. So stereotactic radiation has a lot of different acronyms. SBRT, SRS. I of like SABR, because it almost it's reminiscent of sword, and kind o f feel it's a little empowering to think about it that way. Typically used to treat small tumors.

Now I didn't put a particular dimension by small because that depends upon the area of the body in question. But regardless, the goal is to completely ablate the tumor. So external beam radiation delivered at somewhere in the neighborhood of 1.8 to 2 and 1/2 or so Gray a day, although there are some exceptions.

But typically speaking doses in that range hit a cancer cell, hit normal tissue, and damage DNA in both. But the theory is, the normal cancer cell can repair that DNA damage better than the cancer cells. So over time, lower doses lead to cell death via variety of different mechanisms.

SBRT throws away that playbook and basically says, we're just going to give a high enough dose of radiation that whatever is in the field, it will just be killed and released from a burst of cells. And the way that you can do that is you treat a really small area. So only a small portion of the normal tissue is actually ablated.

Now, this is usually not performed on an urgent basis. This is something that requires a lot of thought, a lot of planning. And again, getting back to that multidisciplinary care I was describing earlier, really experienced surgeons, experienced radiation oncologists, experience physicists all play a key role in doing that.

And there's a lot of different ways to do it, again getting back to the technology piece. There's several different machines that we have access to do this treatment. So Gamma-knife, Cyber-knife, Linac-knfe. So firstly, gamma-knife.

Gamma-knife was pioneered-- and we're very proud of this within the UPMC and University of Pittsburgh system --was pioneered there decades ago. And we continue to be a very active member of that community. Now the pros of gamma. So what do you do when you treat a patient with Gamma-knife?

So typically speaking, this involves both the radiation oncologist and the neurosurgeon and the evaluation of the patient. You have the MRI that you actually fuse to-- you're planning off an MRI actually. The patient's head is very firmly immobilized, either via a frame which is actually lightly screwed into the patient's skull, into the cranium, which is a maximum in regards to minimizing head motion.

Or more recently, because that process again maximizes immobility, but also is a little-- can be disconcerting to a patient, although it's done with in the context of neurosurgeons and that area is topically numbed. But regardless, now also just as frequently, I would say, frameless Gamma-knife is used where again, you use a very tight fitting mask to accomplish much of the same thing. So Gamma-knife is highly conformal.

There is a high degree of immobilization. So there is very, very, very little movement, which we hate movement in radiation oncology, because moving means you're trying to get your tumor out of the field. Now this type of treatment can also be completed in one treatment and is also primarily used in situations for either certain benign tumors of the CNS and also brain metastasis.

Now the cons of Gamma-knife. It is less available than other methods. It is more available than protons, but it's not available at every center. Thankfully it is available at our [INAUDIBLE]. It often requires an invasive immobilization device, which I describe, that frame that screwing into the skull to hold steady. Although again, frameless Gamma-knife is also used.

Now this is limited to the brain and upper C spine. So you're not treating your lumbar metastases with Gamma-knife. And finally, it does take a good long while compared to some of the other modalities of radiotherapy delivery.

So Cyber-knife is a general-- think about a Gamma-knife, but not for here, just for everywhere else. There is no invasive immobilization, number one. It can treat multiple body sites. And you do actually have real time treatment monitoring.

Now the downside for Cyber-knive is that it's less available than other means of radiation delivery. Oftentimes it requires basically putting something in the tumor so you can see it, at fiducial. And finally again, it does suffer from those long treatment times.

And finally Linac based stereotactic radiation. So this is broadly available. Basically throughout our network we have multiple sites, both in Central Pennsylvania and throughout our region where we can perform stereotactic body radiation therapy utilizing our Linac based technology. There's no real invasive mobilization. There's no screws into the skull.

You can treat just about every site that you can imagine with stereotactic radiation, and it's comparatively rapid treatment. Now there is less real time monitoring of treatment. We can do some. We can, for example, do surface guidance. So you can actually visualize the body surface and make sure that it's not moving while you're treating. And that's a relatively recent technology.

And the con is also there's no invasive immobilization. So in theory, if you're using a frame and not the screws into the skull, is there more motion? I don't really think so. But that's certainly something that has been discussed.

Now, if you're looking at clinical trials, there's not been a huge amount in this setting, at least randomized clinical trials. This is a recent one with a lot of, 251 patients with brain metastisis looking at Gamma-knife based radiosurgery versus Linac based surgery. And really very little difference between the two, although you could-- numerically there was a higher level of symptomatic radionecrosis in the Gamma-knife based arm, but again not anywhere near statistically significant between those two treatments.

So suffice to say, there are multiple different modalities to treat with stereotactic radiotherapy and each has their pros and cons. Honestly, I think it depends upon a lot of different factors, local preference, local experience, and constant communication amongst the different referring teams.

So finally brachytherapy, which is actually the most, don't want to say ancient, but the oldest form of radiation to treat cancer. Indeed, I think it was in the late 1800s where an implanted source of radium was first used to treat a cervical cancer, which tells you how long this has been used. And there's a few different ways to do it.

You can actually do what's called intracavitary brachytherapy which is implanting radioactive source within a body cavity. Interstitial, which are actually needles, which can then house a radioactive source which then treats the area where the needle was placed. There are seeds, which are radioactive seeds which are actually implanted into a body organ, usually prostate and actually left there to deliver the radiation over a longer period of time.

And each has again, their pros and cons, just the running theme of this discussion. So for intracavitary brachytherapy. This is highly conformal. All brachytherapy is actually highly conformal, because your radiation is right there, and it doesn't really penetrate very deeply at all. So highly conformal, and can often be performed actually without sedation, because in many body cavities that's not required. However, it is limited by sight, because it is an intracavitary placement. And indeed the most common intracavitary placements that we're doing are for cervical and endometrial cancer.

In some instances they do actually require an operative procedure and/or sedation, I'm thinking cervical cancer in the intact cervix, for example. And they're often operator dependent. And this particularly for brachytherapy, I think it is extraordinarily key to be working with radiation oncologists that have a high degree of experience with brachytherapy.

And that's the one area where I'm really quite proud of our network, both our colleagues in Central PA as well as our colleagues in the western half of the state and the Magee Women's Hospital I think that our experience with brachytherapy is really almost unmatched because it's so important. This is a procedure, and the procedure aspect of it absolutely matters.

And even more so, with in some degree even potentially even more so with interstitial placements. Again, this is highly conformal. Brachytherapy is highly conformal radiation. But this generally requires an operative procedure for placement. Because remember you're putting In needles that will eventually house radiation for a short period of time. And that's always operative.

And finally, seeds. Typically speaking, this is used for prostate radiotherapy. Highly conformal. You're not actually taking anything out. You place the seeds and that's where they are. Again, operative procedure, always operative dependent. And the seeds do remain in place.

And because the seeds remain in place it's important to monitor the patient in the short term after seed implantation. Because let's say for example there is some form of seed migration, you may actually have to go back in and place another one or two seeds to make sure you're getting adequate coverage.

And finally a level of brachytherapy that's less utilized in many instances is surface based brachytherapy. So highly conformal, usually it's not an operative procedure. You're usually placing it on something. Although in some instances, there can be an operative procedure where you're actually placing it in something. I have historically done this occasionally in patients with recurrent head and neck cancer after radiation, where the surgeon is doing a procedure where they remove a lymph node and I can place a surface based radiation treatment there intraoperatively.

But honestly, it's very limited data in my opinion for service based brachytherapy that's constantly in flux and developing. And there's limited application for it functionally. If you can put it on something, usually skin, maybe lip, then you can do it. But again, I think limited application.

So in conclusion, firstly I want to thank you all very much for your kind attention. The most important thing that I want you to take home from this is that radiation is not where it was even five or 10 years ago. There's a lot of different arrows in the quiver, both in regards to technology as well as in regards to approach.

But the most important thing, it's not the fiddle. It's the person holding the bow. It is the experience and the collaborative nature and the multidisciplinary group that you have when you're treating patients with radiation, regardless of modality. So with that, I'd like to conclude the talk. I have references for those that are interested available in the talk as well. And thank you very much for your kind attention.