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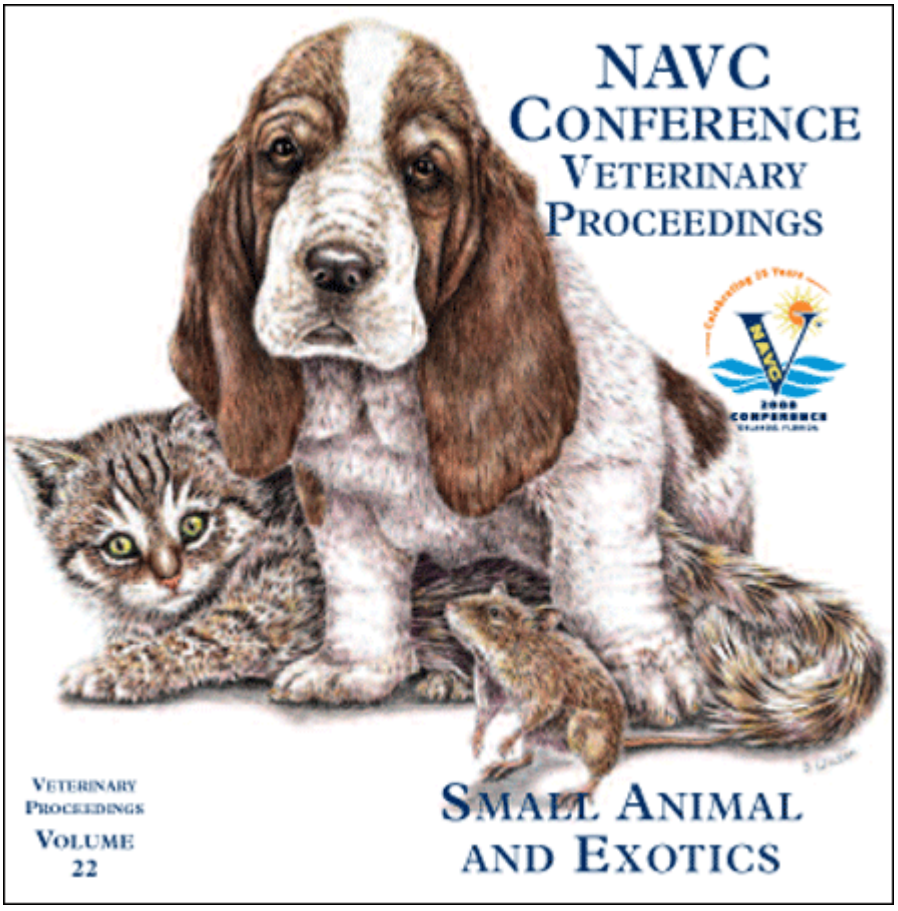

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WHAT CAN I TREAT WITH RADIATION THERAPY?

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Radiation therapy (RT) is becoming an increasingly important part of cancer patient management in veterinary medicine. This article will cover the more commonly used types of RT including external beam radiotherapy and plesiotherapy, which is a type of brachytherapy. Traditionally, external beam RT is thought of as a local therapy, meaning that it is best used to treat the primary tumor and not systemic disease. It is most effective when used against microscopic disease after a tumor has been incompletely excised (postoperative RT) or when used against gross disease with a surgery scheduled to follow (preoperative RT). It is often used in combination with other therapies such as chemotherapy when there is risk of metastasis. There are circumstances, however, where it can be used as the only therapy (eg, nasal tumors), as a systemic therapy (eg, half-body RT for lymphoma), or as a palliative measure (eg, bone tumors).

MACHINES USED TO DELIVER RADIATION THERAPY

There are three main different types of machines used to deliver RT: orthovoltage machines, cobalt-60 machines, and linear accelerators. Orthovoltage machines are not widely used anymore and have the disadvantages of increased skin reactions, no computerized treatment planning systems, small field sizes, and high absorption of dose to bone. Cobalt-60 machines are still in use in veterinary medicine but also have some disadvantages compared to linear accelerators, which include increased penumbra at the field edge (leading to larger treatment fields), lower energy (leading to increased skin dosing) and less penetration of dose. Linear accelerators are becoming more widely used in veterinary radiation oncology and are the standard of care in treating humans. They are able to deliver a variety of energies and many of the newer machines allow treatment with either photons or electrons. Electrons allow the treatment of tumors over critical structures such as the intestine or GI tract without giving substantial dose to these organs. Linear accelerators also allow the use of smaller field sizes than cobalt units and allow a more homogenous dose to be delivered to deep-seated tumors.

HOW RADIATION IS DOSED

The basic unit of absorbed dose is the Gray (Gy). The older unit is the rad. When considering what total dose is going to be given several things need to be taken into account; Specifically: The radiosensitivity of the tumor, the dose delivered in each fraction, the time between fractions, the total number of fractions, the goal of therapy (palliative vs. definitive) and often most importantly the tolerance of the surrounding normal tissues.

While it is possible to kill any tumor cell with radiation, it is not possible to cure or even effectively treat every patient. The limiting factor in our ability to deliver a high and curative dose to a tumor is the effects on the irradiated surrounding normal tissues. Of course large doses of radiation delivered once weekly is more convenient and cheaper than small doses delivered daily, but you are less likely to get long-term control of a tumor and more likely to experience late side effects with coarse or hypofractionated protocols. Late side effects are generally the type that are most severe and can impact quality of life or even become life threatening. The smaller the dose given in each fraction the higher the total dose that can be delivered. Therefore, for patients who are expected to have medium or long-term survival, smaller dose per fraction protocols are the most appropriate. Three Gy delivered at each treatment (fraction) is the most commonly accepted dose used in veterinary medicine for definitive treatment of tumors that are not located in the brain for a total dose of 48–57 Gy. For brain tumors, many radiation oncologists use even lower doses per fraction protocols (2–2.5 Gy per fraction) and will go to a lower total dose of 42–50 Gy. For patients in whom we are trying to relieve pain or reduce clinical signs secondary to their tumor (palliative care) and for whom we are not anticipating survival beyond 6 months, higher dose per fraction protocols of 6–9 Gy in each treatment to a total dose of 24–36 Gy are used. For definitive therapy, the standard of care is daily treatments given Monday through Friday and for palliative therapy, treatments are most often given once weekly or for some protocols two concurrent days.

THE BASICS OF TREATMENT PLANNING

Hand Planning

If we are treating an area surrounding a scar from an incompletely excised soft tissue sarcoma or mast cell tumor for example we will often use a hand plan. If no gross disease is present and it is in an area where we are not as concerned about dose to the normal tissue then we will often plan by hand. This is done by placing an appropriate margin around the scar and then calculating an appropriate dose to the desired depth, taking into account the skin and exit doses.

Computer Planning

With the advent of computer, planning radiation plans with multiple beams can be easily made using advanced imaging such as CT and MRI. Most treatment planning systems use CT scans for treatment planning since it provides density information for dose calculation and because it provides better geometric accuracy than MRI. Many of these programs will allow fusing of an MRI image to a CT scan, allowing us to take advantage of the superior soft tissue detail seen with MRI while still providing the information from the CT. This is particularly useful when planning brain tumors, which are much better visualized on MRI than CT. For most other tumor types, usually a CT alone is sufficient.

For treatment planning the patient is scanned in the position that they will be treated in using any patient positioning devices that you plan to use. This allows for the most accurate set-up later. The CT is then imported into the program. The area to be irradiated is then identified and marked. The gross tumor volume (GTV) is the visible tumor. The clinical target volume (CTV) is the GTV plus an appropriate margin for the tumor type. The margin for the CTV is based on the tumor type and its biological behavior. The planning target volume is the CTV plus an appropriate margin that takes into account patient/organ movement, set-up variation and machine limitations. While the GTV and CTV are set by the tumor itself, limitations in technology help determine the PTV. Advanced imaging, more modern equipment and patient positioning devices can all allow us to shrink the PTV.

Three-dimensional (3-D) treatment planning systems let you visualize dose on a 3-D image and also allow creation of dose volume histograms, which are graphs that let you see what volume of tissue is receiving what dose of radiation. This is useful in ensuring that the tumor is receiving the desired dose and that normal structures (such as lung, spinal cord or eyes) are getting the minimal dose possible. Individual plans can then be compared.

TUMOR RESPONSE

The effectiveness of radiation therapy depends on many factors including the type of tumor, its location, whether it is localized or not and the quality of the radiation plan as well as the ability of a facility to carry out that plan in a reproducible manner. The rest of this session will cover some of the more common tumor types treated with external beam RT and the expected outcome with treatment.

Squamous Cell Carcinoma

When treating squamous cell carcinoma location and species differences are key. While squamous cell carcinoma of the oral cavity in dogs is very responsive to treatment with a reported 1-year survival of over 75%, it is a relatively ineffective treatment for cats with oral squamous cell carcinoma. In contrast, squamous cell carcinoma on a cat's nasal planum is very responsive to radiation therapy and may be curative, while those on a dog's nasal planum are not.

Mast Cell Tumors

Most mast cell tumors can be effectively managed by surgery alone. If microscopic disease is left behind, RT can be used to treat the area. The reported outcomes are very good with 5-year survival rates of 86% reported for incompletely resected Mast cell tumors treated with radiation therapy. Grade and stage are very important in determining prognosis, but even higher-grade tumors or those that have spread to the local lymph node can be effectively treated with RT as part of their treatment protocol. In one report in dogs with grade II mast cell tumors that had metastasized to the local lymph node the median disease-free survival was 1,240 days. Dogs with grade 3 mast cell tumors are also reported to do well after surgical resection and irradiation of the primary tumor area and local lymph node with a median survival of 28 months. It would be advisable to consider chemotherapy in these patients as well to try to treat potential metastatic disease.

Soft Tissue Sarcomas

Incompletely resected soft tissue sarcomas are commonly seen. While additional surgery may be possible and curative, radiation therapy is used when surgery will not result in a complete resection or will require limb amputation. With the advent of electron therapy it is also possible to treat tumors on the thorax or abdomen without causing damage to the underlying normal tissue. While outcome depends on grade, median disease free intervals of nearly 3 years and median survival of 5 years have been reported.

Pituitary Tumors

Dogs with pituitary macroadenomas, whether or not they have pituitary dependent hyperadrenocorticism, often respond well to radiation therapy. While radiation won't necessarily control signs of Cushing's disease, it is often able to control neurological signs, improve quality of life, and extend survival compared to untreated dogs. In a recent study looking at 19 dogs treated with full course radiation therapy median survival was not reached and mean survival was 1405 days with 1-, 2-, and 3-year survivals of 93%, 87%, and 55%, respectively. Both the height of the tumor compared with the skull height and the area of the tumor compared with the brain area were prognostic for survival.

Nasal Tumors

For a more detailed description of nasal tumors please see the previous article on nasal tumors in these proceedings. In dogs, the most common tumor types include nasal carcinomas while sarcomas are less common. In cats, the most common type of nasal tumor is lymphoma. Radiation therapy is very useful in the management of nasal tumors. In a recent study of cats with nasal lymphoma treated with radiation therapy and six-months of chemotherapy median survival was 955 days. The only prognostic variable identified was cribriform plate destruction. For dogs, median survivals for carcinomas range from 8 to 12 months and for sarcomas median survival ranges from 12 to 18 months.

Brain Tumors

The most commonly treated brain tumor in dogs is a meningioma. There are several studies, which suggest that radiation therapy used alone or in conjunction with surgery can extend life. In one study dogs treated with surgery alone had a median survival of 7 moths while those treated with RT and surgery had a median survival of 16.5 months. In another paper looking at dogs with brain masses causing neurologic signs median survival was reported at 699 days with RT.

Thyroid Tumors

Thyroid tumors are also considered to be responsive to radiation therapy. Surgery and radiation are often combined in the treatment of these tumors with reported median survivals of over 2 years. Even with large non-resectable tumors, outcome can be good. One study reported a median survival of over 24 months while another reported progression-free survival rates of 80% at 1 year and 72% at 3 years.

Oral Melanoma

Radiation therapy can be used to treat local disease in dogs and cats with oral melanoma. Most often this is done using a coarsely fractionated protocol with reported median survival rates of 6 to 8 months. Most dogs do not die from their local tumor but of metastatic disease. In cats with oral melanoma treated with radiation therapy there is a case series, which reported a median survival of 146 days.

Osteosarcoma

Radiation can be used to help palliate the pain caused by primary bone tumors such as osteosarcoma in dogs. It can be very helpful in cases where owners do not want to amputate the affected limb but do want to try to control the dog's pain and extend life. Median survival has been reported at 4 to 6 months with about 75% of the dogs having some relief of their pain.

Injection Site Sarcomas

Radiation therapy plays an important component in the treatment of injection site sarcomas in cats. Either in the preoperative or postoperative setting radiation extends both the progression free interval and overall survival. Median survival has been reported as high as two years.

References are available from the author upon request.