

Radiation Therapy

The use of ionizing radiation (x-rays, gamma rays, electrons, etc.) in treating disease is called Radiation Therapy. Ionizing radiation is the localized release of large amounts of energy that will break chemical bonds.



Radiation Therapy Cobalt

There are three types of machines used for radiation therapy. An Orthovoltage machine uses electricity to produce low energy x-rays. These machines are used primarily for skin tumors and have a short focus to skin distance. A Cobalt-60 machine uses a radioactive isotope that produces gamma photons as the source decays. The cobalt source has a half-life of 5.27 years and should be replaced about every five years. The focus to skin distance for a cobalt machine is usually 80cm. Linear accelerators use megavoltage x-rays or electrons to create the energy for the radiation treatment. The dose's penetration of the tissue can be regulated to treat the tumor superficially and protect underlying structures. Linear accelerators have a longer focus to skin distance (usually 100cm) and can operate with larger treatment field sizes.

There are many different ways of delivering the radiation to the diseased area. Teletherapy is treatment with the radiation source at a distance away from the patient. Surface Brachytherapy is treatment with the radiation source touching or on the surface (skin) of the patient. In Interstitial Brachytherapy, the radiation sources are in the form of "seeds", ribbons or needles that are placed through or within the tumor. The type of treatment is determined by the tumor's characteristics, the types of adjacent normal tissues, the possibility of combining radiation with another treatment (chemotherapy, surgery, etc.), and the types of radiation available for treatment.

The types of radiation therapy described above are used to treat tumors localized to one site or anatomical region. Because of the tumor's size or position it may be difficult to remove it with surgery or once removed microscopic examination of the tissue edges may show "dirty margins". Radiation therapy may also be used after other treatments have failed.

Some of the tumors treated with radiation therapy occur on the skin and subcutaneous tissues (squamous cell carcinomas, mast cell tumors, and fibrosarcomas) and in bone and areas neighboring bone (nasal adenocarcinomas, chondrosarcomas and osteosarcomas).

All kinds of animals can be treated with radiation therapy. Dogs, cats (domestic and non-domestic), horses, cattle, goats, sheep, snakes, birds and primates have all undergone radiation therapy.

How Does Radiation Therapy Work?

Radiation therapy is based on the principal that ionizing radiation kills proliferating cells. Most likely, the DNA contained in the cell is damaged. This interferes with the cell's ability to divide and the cell dies. Proliferating cells of normal tissues may be equally as sensitive to radiation as tumor cells. The total radiation dose that can be given is determined by the most radiosensitive critical normal tissue in the treatment volume.

Tumor cells may be hypoxic. Vascularization or blood flow is frequently poor in many solid tumors. Because of this, the tumor cells receive less oxygen, or are hypoxic, and are less sensitive to injury by irradiation. Well oxygenated cells that are actively proliferating are more radiosensitive.

Fractionation

If the radiotherapy is given in one large dose, severe tissue damage will occur to the normal surrounding tissue. Fractionation decreases the amount of normal tissue damage (see Repair). Increased fractions with a decreased dose of radiation per fraction will cause fewer acute tissue reactions. This allows a higher dose to be given to the tumor with less damage to the normal tissue. A dose that would kill an animal if given all at once can be used in tumor treatment if it is divided and given in fractions over 4-6 weeks. In veterinary medicine, a common total dose would be 48-60 Gray (1 Gray = 1Gy = 100 centigray or Rads) given over 12-20 fractions in 4 weeks. The number of fractions depends on the type of tumor, the normal tissues within the treatment field, and the patient's condition. Some patients get palliative treatments to decrease pain that consist of 3-6 fractions of 6-10 Gray each. Palliative patients are usually treated once or twice a week. Patients whose treatment is a curative plan are treated Monday through Friday.

Radiosensitivity

The radiosensitivity of given cells can be measured by their loss of reproductive activity (see Reassortment). Normal muscle and nerve cells do not divide and are relatively radioresistant. Stem cells of bone marrow, skin and gut regularly divide and are much more sensitive to radiation injury.

Normal tissue radiation tolerance varies greatly and depends on the type of tissue, the volume being treated, and the number of days over which the total radiation dose is delivered.

During localized radiation of a tumor only a small area of bone marrow would be irradiated and hematopoietic damage, as seen during a total body irradiation, is not a complication.

Reactions

Radiation injuries to normal tissues are classified as acute or late reactions. Acute radiation reactions are primarily due to epithelial cell responses (i.e., skin, mucous membranes, lining of the gut, etc.). These cells divide regularly in a time of days or weeks to months. Their injury manifests itself in skin reactions ranging from epilation (hair loss), erythema (reddening), dry desquamation (flaky skin), moist desquamation (blistering), and finally skin necrosis. The more radiation damaged cells try to divide, the more cells will die. Therefore, during and immediately following irradiation, no irritation to the tissue in the treatment field should be allowed. The animal must not lick, rub, or scratch the area and no invasive procedures should be performed. Antibiotics may be given to prevent any infections in the treated tissue.

The second type of injury, late normal tissue reactions, reflect radiation damage to endothelial and connective tissues. If the animal's eye was in the treatment field, dry eyes and corneal ulcers can result about 6 months following the end of radiation therapy. One to two years after the radiation therapy, lens opacification can occur. Bone in the irradiated area should not be biopsied for at least two years to avoid an increased chance of fracture.

We all know that radiation can cause cancer as well as cure it. However, there is less than a 1% chance that a new tumor will develop in the old treatment field as a result of therapeutic radiation therapy.

Radiation Therapy and Other Modalities

Radiation therapy can be combined with other types of treatments to give the patient the best chance of cure. Surgery can be done before radiation therapy to decrease the amount of the tumor and normal tissue that must be irradiated.

Radiation therapy may be given prior to surgery to diminish the potential for metastasis from tissue manipulation. Microscopic disease may also be eliminated by radiation therapy before surgery. Occasionally a surgeon is unable to cleanly excise the tumor and the surgical site will need to be irradiated to eliminate residual tumor cells. Unfortunately, surgery occasionally must be performed to remove a tumor that has recurred after radiation therapy due to a "geographic miss". This is why it is essential to have current radiographs, CT and/or MRI of the treatment area to completely localize the tumor margins for optimal treatment.

Chemotherapy can be given along with radiation therapy as a radiosensitizing drug that mimics the effect of oxygen in the tissue allowing better irradiation of the tumor. However, because the normal tissues can be damaged by both chemotherapeutic drugs and radiation, animals undergoing multiple types of therapy treatments must be carefully monitored to assure the combination therapy does not become "lethal".

A Typical Treatment

In preparation for a Cobalt-60 therapy treatment at the University of Illinois, the animal is fasted after 10:00pm. Each radiation therapy patient must be sedated or anesthetized to insure that it will not move during the treatment. Since no pain is involved in the teletherapy procedure, drugs are usually given in as small of a dose as possible. The dose is dependent on each particular patient's physical condition and previous reaction to the given group of sedatives it is receiving. We are currently using a combination of atropine or glycopyrrolate with butorphanol and medetomidine. This "cocktail" can be reversed with atipamezole once the radiation therapy has been completed. Propofol has been given as an induction agent followed by anesthesia with Isoflurane for patients who may have physical problems that would preclude the use of the regular combination of drugs. Ketamine, diazepam, acepromazine, and oxymorphone have also been used for sedating patients for radiation therapy.

The patient's dose for treatment using the Cobalt-60 machine is calculated using several factors. The daily dose rate available from the cobalt must be known. The amount of centigray or Gray per fraction, the depth of the tumor, the size of the field and the daily dose rate must all be entered into the equation that will determine the time of the treatment. The only way we can regulate the amount of the dose from the cobalt machine is by varying the length of time the machine is on.

Once the animal is sedated and sleeping quietly on the treatment table it is placed in the required treatment position and secured to the table with adhesive tape. The treatment position must be precise and easily repeatable to insure the

optimal dose of radiation to the affected area. To successfully treat a tumor, the positioning must be as close to 100% repeatable as possible.

The distance from the cobalt source to the surface of the skin or center of the tumor must be precisely 80cm for our Theratron-780 Isocentric teletherapy unit's calculations.

The radiation dose from Cobalt-60 gamma photons is 95% at the skin surface and 100% at .5cm below the surface of the skin. The dose decreases as it goes deeper into the tissue with a 50% dose occurring at about an 8cm depth. If a tumor is located on the surface of the skin, .5cm of soft-tissue dense material (i.e. .5cm of wet cotton batting) is applied to the site to assure that 100% of the dose reaches the superficial tumor. This material is referred to as a "bolus".

Because all the area to be radiated may not be the same thickness, we sometimes need to use what is called a "tissue compensator" to give a more homogeneous dose to the treatment site. A dog's head has varying thickness' which cause the radiation dose to vary. A tissue compensator is used to fill in the difference in thickness and even out the dose to the entire head. These compensators can be made of Plexiglas or lead and may be made to fit on trays attached to the radiation therapy machine.

Once the animal is correctly positioned and any necessary boluses or treatment compensators are applied to the treatment site, a camera is aimed at the patient. This is to allow the technician to closely observe the patient during the treatment to observe respiration and movement as no one is allowed in the therapy suite while the cobalt machine is on. The actual treatment times will vary depending on the dosage required by the particular patient. The animal may require anywhere from 1 to 4 ports for its radiation therapy treatment, with the cobalt machine being repositioned for each port of the fraction. A portal is the angle and direction of the radiation beam.

Once the radiation therapy is completed, the animal is reversed, recovered and returned to its cage or run. There is no need for a warning sign to be placed on the animal's cage because the patient is not emitting any radiation.

Treatments may be given daily, every other day or once a week depending on the treatment plan prescribed for the specific patient.

Summary

Radiation therapy may be used on many different types of tumors and animals. The type of radiation therapy given is determined by the tumor type and location, the available types of radiation therapy and the physical condition of the patient. The ionizing radiation damages proliferating cells, both tumor and normal, and

effects their ability to divide. Radiation therapy may be used alone or in conjunction with other types of treatment. Used correctly, radiation therapy can be a useful tool in tumor control.

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