Intensity-Modulated Radiation Therapy (IMRT)



Intensity-modulated radiotherapy (IMRT) uses linear accelerators to safely deliver precise radiation to a tumor while minimizing the dose to surrounding normal tissue.

Your radiation oncologist will speak with you to determine whether IMRT is the most appropriate treatment for you.

What is Intensity-Modulated Radiation Therapy and how is it used?

Radiation therapy, including IMRT, damages the DNA and stops cancer cells from dividing and growing, thus slowing or stopping tumor growth. In many cases, radiation therapy is capable of killing all of the cancer cells, thus shrinking or eliminating tumors. Radiation therapy may be used in conjunction with surgery (adjuvant radiation). In this scenario, radiation targets potential microscopic disease after surgery.

Intensity-modulated radiation therapy (IMRT) is an advanced mode of high-precision radiotherapy that uses computer-controlled linear accelerators to deliver precise radiation doses to a malignant tumor or specific areas within the tumor. IMRT allows for the radiation dose to conform more precisely to the three-dimensional (3-D) shape of the tumor by modulating—or controlling—the intensity of the radiation beam in multiple small volumes. IMRT also allows higher radiation doses to be focused on the tumor while minimizing the dose to surrounding normal critical structures. Treatment is carefully planned by using 3-D computed tomography (CT) or magnetic resonance (MRI) images of the patient in conjunction with computerized dose calculations to determine the dose intensity pattern that will best conform to the tumor shape. Typically, combinations of multiple intensity-modulated fields coming from different beam directions produce a customized radiation dose that maximizes tumor dose while also minimizing the dose to adjacent normal tissues.

Volumetric modulated arc therapy (VMAT) is a form of IMRT in which the radiation dose is delivered continuously during one or more gantry rotations of up to 360 degrees, with simultaneous real-time modulation of multileaf collimator (MLC) leaf positions, variable dose rate, and gantry speed. In contrast, step-and-shoot IMRT delivers radiation through a limited number of fixed beam angles with the beam turned off while the MLC leaves move to new positions between segments. Both techniques are useful and there are clinical situations where one technique might be preferred over the other.

Because the ratio of normal tissue dose to tumor dose is reduced to a minimum with the IMRT approach, higher and more effective radiation doses can safely be delivered to tumors with fewer side effects compared with conventional radiotherapy techniques. IMRT also has the potential to reduce treatment toxicity, even when doses are not increased.

Who will be involved in this procedure?

Most facilities rely on a specially trained team for IMRT delivery. This team includes the radiation oncologist (http://www.radiologyinfo.org) , medical physicist (http://www.radiologyinfo.org) , dosimetrist (http://www.radiologyinfo.org) , radiation therapist (http://www.radiologyinfo.org) and radiation therapy nurse (http://www.radiologyinfo.org) .

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The radiation oncologist, a specially trained physician, first consults with the patient to determine whether IMRT is the most appropriate treatment. After obtaining informed consent, the individualized course of treatment is planned.

A radiation physicist, who has specialized training in the field of medical physics, ensures the linear accelerator (http://www.radiologyinfo.org) delivers the precise radiation dose and that computerized dose calculations are accurate.

A dosimetrist works with the medical physicist to develop the IMRT plan and beam configurations necessary to deliver the dose prescribed by the radiation oncologist.

The final treatment plan is verified by the medical physicist on the treatment machine using a phantom (a device that simulates the human body) that measures the dose delivered by the treatment plan. This ensures that the dose planned by the radiation oncologist is the dose delivered by the machine.

A radiation therapist positions the patient on the treatment table and operates the machine.

The oncology nurse assesses the patient during the course of treatment and provides the patient with additional information about the treatment and possible adverse reactions. The radiation oncology nurse also helps in managing any reactions or side effects from treatment that may occur, in collaboration with the physician.

What equipment is used?

A medical linear accelerator (LINAC) generates the photons, or x-rays, used in IMRT. The machine is the size of a small car—approximately 10 feet high and 15 feet long. During the treatment, the patient must lie still. The intensity of each beam's radiation dose is dynamically varied according to treatment plan. The patient will not feel any sensation while the radiation is on, but will hear noise from the machine, and may smell an odor from the electronic equipment, or see the warning indicator light. The noises and odors from the machine are normal. The patient will be in the room alone during treatment but is constantly monitored by the radiation therapists from outside the treatment room. The time in the treatment room depends on the specific plan, but usually is between 10-15 minutes.

See the Linear Accelerator (https://www.radiologyinfo.org/en/info/linac) page for more information.

Who operates the equipment?

The radiation therapist operates the equipment from a radiation-protected area nearby. The radiation therapist is able to communicate with the patient throughout treatment and observes the patient on closed-circuit television.

Is there any special preparation needed for the procedure?

Before planning treatment, a physical examination and medical history review will be conducted. Next, there is a treatment simulation session, which includes CT scanning. A small mark or tattoo may be placed on the patient's skin to help align and target the equipment. The radiation oncologist uses this scan to make an individual plan for the patient. In some cases, a mask or other device to keep the patient still during treatment will be made. Sometimes the patient is instructed to follow a certain bowel and bladder preparation regimen or to fast prior to the simulation and treatment. Intravenous contrast material may be injected during the CT scan to help define the tumor better.

Occasionally, additional scanning procedures, including positron emission tomography (PET) and magnetic resonance imaging (MRI), might also be required for IMRT planning. These diagnostic images can be merged with the planning CT and help the radiation oncologist determine the precise location of the tumor target.

In some cases, it is necessary to insert radio dense markers into the target for more accurate positioning. Typically, IMRT sessions

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begin about a week or two after simulation.

How is the procedure performed?

IMRT often requires multiple (fractionated) treatment sessions on different days. The radiation oncologist considers the type, location and size of the tumor, doses to normal structures, and the patient's health to decide the number of treatments. Typically, patients are scheduled for IMRT sessions five days a week for five to eight weeks.

At the beginning of the treatment session, the radiation therapist positions the patient on the treatment table, guided by the marks on the skin (tattoos) defining the treatment area. If molded devices were made, they will be used to help the patient maintain the proper position. The patient may be repositioned during the procedure. Imaging systems on the treatment machine such as x-ray or CT may be used to check positioning and marker location. Most patients spend no more than 10-15 minutes on the treatment table daily, which includes treatment set up and imaging.

What will I feel during and after this procedure?

As with other external beam radiation therapy treatments, there is no pain expected during the actual treatments with IMRT. However, the machine can be stopped if a patient experiences discomfort due to the treatment position or positioning devices. As treatment progresses, some patients may experience treatment-related side effects. The nature of the side effects depend on the normal tissue structures near the tumor that are being irradiated. The radiation oncologist and the nurse will discuss potential side effects and the management of those side effects.

Radiation treatment can cause side effects. These problems may result from the treatment itself or from radiation damage to healthy cells in the treatment area.

The number and severity of side effects will depend on the type of radiation, dose, and body part under treatment. Talk to your doctor and/or nurse so they can help manage them.

Radiation can cause early and late side effects. Early side effects happen during or right after treatment. They are typically gone within a few weeks. Common early side effects include fatigue and skin problems. Skin in the treatment area may become sensitive, red, irritated, or swollen. Other changes include dryness, itching, peeling, and blistering.

Depending on the area being treated, other early side effects may include:

- hair loss in the treatment area
- mouth problems and difficulty swallowing
- eating and digestion problems
- diarrhea
- nausea and vomiting
- headaches
- soreness and swelling in the treatment area
- urinary and bladder changes

Late side effects may occur months or years following treatment. While they are often permanent, they are rare. They include:

- brain changes
- spinal cord changes
- lung changes
- kidney changes

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- colon and rectal changes
- infertility
- joint changes
- lymphedema
- mouth changes
- secondary cancer

There is a slight risk of developing cancer from radiation therapy. After treatment, your radiation oncologist will regularly check for complications and recurrent or new cancers.

Using techniques such as IMRT, radiation oncologists maximize the cancer-destroying capabilities of radiation treatment while minimizing its effect on healthy tissues and organs side effects.

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