Varian's Smartbeam Intensity Modulated Radiation Therapy (IMRT): The Technology

Varian Medical Systems' SmartBeam IMRT — Intensity Modulated Radiation Therapy — uses computer-generated images to plan and then deliver even more tightly focused radiation beams to cancerous tumors than is possible with conventional radiotherapy. With this capability, clinicians can exquisitely "paint" a precise radiation dose to the shape and depth of the tumor, while significantly reducing the adverse effects of doses on healthy tissue. SmartBeam IMRT, an advanced form of 3-dimensional conformal radiotherapy (3D-CRT), enables doctors to deliver substantially more cancer-killing energy (generally X-rays) to tumors while decreasing potentially harmful doses to surrounding healthy tissue.

Clinical studies indicate that higher dose rates delivered with IMRT techniques are improving the rate of local tumor control. Recent studies[1] in prostate cancer patients have shown that higher radiation doses (anywhere between 13 and 25 percent higher than commonly used in conventional radiotherapy) more than doubled the rate of local tumor control from 43 to 94 percent. With IMRT, clinicians were able to deliver these higher doses while simultaneously reducing the rate of certain normal tissue complications from 10 percent to 2 percent.

SmartBeam IMRT helps radiation oncologists achieve this increased precision through a combination of computerized machines (called medical linear accelerators), that produce and deliver the radiation, advanced planning and control software, and specialized mechanical devices used to shape or "sculpt" the radiation beams. Varian Medical Systems, Inc., the world leader in integrated cancer care systems, offers a complete suite of hardware, software, and support services for delivering IMRT treatments. Major system elements include:

Varian's Clinac 23 EX Linear Accelerator

- Image acquisition software - for linking diagnostic images such as CT scans into the treatment planning process.

- Treatment planning software – for calculating the number of beam angles, beam shapes, exposure times and the treatment schedule needed to deliver the prescribed dose to the tumor while minimizing the exposure of surrounding healthy tissue.

- Ximatron® treatment simulators – for generating low-energy X-ray images that can be used to locate the tumor, position the patient on the treatment couch, and review the IMRT treatment plan.

- Clinac® EX Platinum medical linear accelerators – used for delivering therapeutic X-ray (photon) or electron radiation doses to the diseased site.

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- Dynamic multileaf collimators – computer-controlled mechanical devices that use up to 120 movable tungsten "leaves" that can conform the shape of the radiation beam to the shape of the tumor from any angle.

- Treatment verification systems – imaging hardware and software that capture and process image beams exiting the patient's body to review treatment delivery and verify that the prescription was delivered properly.

- Radiotherapy department information systems – for managing a patient's complete cancer care regimen - from scheduling, through treatment, through billing.

How Does a Medical Linear Accelerator Work?

Medical linear accelerators are the key systems used for delivering radiotherapy treatments. Standing approximately nine feet tall by nearly 15 feet long and weighing as much as 18,700 pounds, the accelerator consists of four major components: an electronics cabinet called a "stand," housing a microwave energy generating source; a rotating gantry containing the accelerator structure that rotates around the patient; an adjustable treatment couch; and operating electronics. Accelerators are located within specially constructed concrete treatment rooms to provide X-ray shielding.

In operation, microwave energy, similar to that used in satellite television transmission, is used to accelerate electrons to nearly the speed of light (186,000 miles per second). They attain this velocity in a short distance, typically one meter or less. As they reach maximum speed they collide with a tungsten target, which in turn releases photons, or X-rays, with such energy they are measured in millions of volts (MV). Certain models can be switched so that the electrons bypass the target for direct electron therapy. This energy is measured in millions of electron volts (MeV). Radiation oncologists and physicists use electron or photon therapies for different types of cancer treatments.

As the radiation strikes human tissue it produces (largely from naturally occurring water in the body) highly energized ions which are lethal to both normal and malignant cells. While both good and bad cells suffer from radiation, healthy cells can adapt over successive regenerative cycles. Malignant cells do not possess this adaptation mechanism and thus do not survive, a fact which generally dictates the practice of administering repeated radiation treatments rather than a single blockbuster dosage.

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(1) "Clinical experience with intensity modulated radiation therapy (IMRT) in prostate cancer," Michael J. Zelefsky et al, *Journal of Radiotherapy & Oncology*, 55(3) (2000) pp. 241-249.

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