The Wonders of Physics in Radiation Therapy

A Glossary of Team Members and Terms Involved in the Specialty

Radiation oncology specializes in the treatment of cancer with radiation. The treatment technique is referred to as radiation therapy or radiotherapy, and the radiation used can be X-rays, gamma rays or charged particles, such as electrons and protons produced with specialized high-technology equipment or with radioactive sources.

The Team

The radiotherapy team typically consists of radiation oncologists, medical physicists, electronic engineers, dosimetrists and radiotherapy technologists (radiotherapists). Professionals in the physics field and electronic engineers are responsible for discovering, developing and managing the various processes and continually evolving, state-of-the art equipment used in cancer centres throughout the world.

Most patients never meet the physicists who work in cancer clinics or in research labs, but it is important to know that without contributions by physicists, this treatment modality would not exist.

Medical physicists are critical to the success of radiation therapy treatment; and physics researchers are daily studying new methods to make these treatments even more targeted in destroying cancer cells in the tumour, while protecting healthy tissue and organs surrounding the tumour.

Keynote: Dr. Ervin Podgorsak presents *Vignettes from Canadian Medical Physics: 1970 -2010*

Dr. Ervin B. Podgorsak, medical physicist and professor at McGill University, has been intimately engaged in the medical physics field for more than 40 years. He will be presenting *Vignettes from Canadian Medical Physics: 1970 -2010*, as the CARO lecturer at the annual scientific meeting of the Canadian Association of Radiation Oncology (CARO) in Vancouver, September 22 to 25.

“Radiation therapy is an approach to cancer treatment in which electromagnetic energy is used to destroy cancer cells,” explains Dr. Podgorsak. “Electromagnetic energy is light energy that occurs naturally. Radio waves, visible light, X-rays and gamma rays are all types of electromagnetic waves; the difference between them lies in the amount of energy they carry, or wavelength they possess.”

“Light and other types of electromagnetic radiation consist of packets of energy or particles called photons. Depending on their energy, photons can penetrate into, and pass through solid matter and, in doing so, they interact with matter. This allows a radiation oncologist to

treat with radiation any part of the body, such as surface lesions, as well as deep-seated tumours. Radiation therapy uses advanced technology medical devices to create the very high energy or short wavelength radiation beams to kill cancer cells."

According to Dr. Podgorsak, "American medical physics sets the world standard of medical physics and serves as a role model around the world; however, Canadian medical physics also has a long and illustrious history, and is characterized by high professional standards, respectable research productivity, and outstanding accredited teaching programs. Canadian medical physics meets and in several areas even exceeds American standards."

Medical Physicists are scientists who are experts in the planning of radiation treatment including the calculation of dose distribution in the patient as well as calibration of radiation-emitting high technology equipment. Their primary role is to assure that the highest level of quality care in terms of dose delivery to the patient is maintained. The radiation oncologist frequently consults with the medical physicist to help design a difficult or unusual radiotherapy treatment. Medical physicists are also responsible for carrying out the quality assurance procedures of every treatment plan before it is implemented on a patient as well as, in collaboration with radiation oncologists, for specifying, selecting, commissioning and calibrating the equipment and computers used to plan and deliver radiation therapy.

Dosimetrists work in the medical physics field, and specialize in developing patient treatment plans. Patients will have three-dimensional images taken of their anatomy, using technologies such as computer tomography (CT), magnetic resonance imaging (MRI) and positron emission tomography (PET). These images are highlighted within a computer system, which allows for the definition of the cancer or gross tumour volume, and the critical structures surrounding the tumour that must be limited in their exposure to radiation. This information goes to the radiation oncologist who defines the tumour volume and sensitive structures. The dosimetrist then performs calculations of optimal dose distribution for a particular patient, the medical physicist verifies the treatment plan, and the plan is sent back to the radiation oncologists for final verification and dose prescription.

Electronic Engineers are an important component of the medical physics team as they maintain and service the radiation therapy equipment.

Radiation Physics Researchers in collaboration with radiation oncologists are at work to develop novel cancer radiation treatments that improve the radiation treatment outcomes and lives of patients.

Medical Physics is based on the understanding of the scientific principles of the interaction between radiation and the human body. In the case of radiation oncology, cancer cells are acted upon by high energy x rays. The x rays deposit energy in tissue, and the absorbed energy per unit mass of tissue is called the absorbed dose. This energy causes cancer cells to die, but the precise application of such energy must be exact so as to avoid damaging normal healthy cells surrounding the tumour. By treating a tumour from a number of different directions and avoiding normal tissue as much as possible through optimizing the radiation treatment plan, the tumour is destroyed without causing serious side effects.

Canadian Association of Radiation Oncology
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Types of External Beam Radiation Therapy

Linear Accelerators for External Beam Radiation Therapy

Most important machines for external beam radiotherapy are the cobalt teletherapy machine and the linear accelerator (linac). Cobalt units were invented in Canada in the 1950s by Dr. Harold E. Johns, the most illustrious Canadian medical physicist. For several decades after 1950 the cobalt machine producing gamma rays was the most important machine in the radiotherapy armamentarium. It is still heavily used in the developing world, however, modern radiotherapy is now delivered with high-energy linear accelerators producing either high-energy x-ray beams or high-energy electron beams. Most of the radiotherapy is carried out with high-energy x-ray beams. These beams consist of much higher energies than a standard diagnostic x-ray machine and must be meticulously maintained and calibrated in order to guarantee patient safety and optimal radiation treatment. Physicists are responsible for regular quality assurance measurements on all high technology equipment that is used for patient treatment in the radiation oncology department.

Conventional external beam radiation therapy - The science of radiation oncology and medical physics has developed standard approaches to dose delivery. In many cancer cases the treatment approach may be very similar and allows for conventional treatment.

For example, many tumours can be treated with a single field from the front and a single field from the back or with two fields from the opposite sides. These are examples of parallel-opposed fields. The combination of fields helps to uniformly deliver dose across the tumour and minimize the dose delivered to tissues outside the tumour. Sometimes three or four fields will be used. Occasionally, the gantry of the linear accelerator will rotate during treatment using what is called arc therapy.

3-D Conformal Radiation Therapy - Through the advancement of imaging technology enhanced images of the body allow for programming of treatment beams to conform better to the shape of a tumour. Hence treatment is more effective and side effects are reduced. By treating with large numbers of beams each shaped with a multileaf collimator (MLC) or cerrobend block, radiation dose is delivered uniformly and conformally to the tumour.

Intensity Modulated Radiation Therapy (IMRT) - IMRT is one of the latest advancements in radiation therapy. This new approach to treatment allows for dose sculpting and even distribution of delivery to avoid critical structures while delivering precise uniform treatment. In this technique, the multileaf collimator (MLC) moves and modulates the radiation as the linac treats the patient.

Brachytherapy - is a form of radiation therapy in which a radioactive source or radioactive seeds are placed very close to the tumour or are inserted into the tumour. This involves exposure of cancer cells to radioactive material rather than through external beam treatment. In brachytherapy the effective distance of the radiation source is small so effects on healthy tissue are reduced. In some cases, the seeds are permanently implanted and the patient is allowed to leave shortly after the procedure is completed.

The origin of medical physics dates back to the last decade of the 19th century when Wilhelm Röntgen discovered X-rays in 1895. Henri Becquerel discovered natural radioactivity in 1896, and Marie Curie and Pierre Curie discovered radium-226 in 1898. It was Alexander Graham Bell who suggested radium use in brachytherapy for direct implantation in malignant tumours.

References:

- Dr. Ervin B. Podgorasak, medical physicist and professor at McGill University.
- CARO-ACRO board member and annual scientific meeting chair, Dr. Eric Vigneault, radiation oncologist, CHUQ-L'Hotel-Dieu de Quebec.
- Johns Hopkins Radiation Oncology Department website.
- BC Cancer Agency Patient Information website.

A photo of Dr. Ervin Podgorsak is available on the CARO-ACRO web site online newsroom at **http://www.caro-acro.ca/Meetings__Education/Annual_Scientific_Meetings/24th_Annual_Scientific_Meeting_September_22_-_September_25__2010_Vancouver__BC/2010_ASM_Media_Kit.htm**

He will also be available for interviews.

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About the Canadian Association of Radiation Oncology – Association canadienne de radio-oncologie (CARO-ACRO) (www.caro-acro.ca)

CARO-ACRO is a national organization representing Canadian radiation oncologists, and other professionals in the radiation therapy field, to promote the interests of radiation oncology in Canada, and to represent the specialty to governments, The Royal College of Physicians and Surgeons of Canada and other national and international societies.

The mission of CARO-ACRO is to: represent and support its membership nationally and internationally through the promotion of high standards of patient care in the practice of radiation oncology; to support excellence in professional standards: and to promote radiation oncology research and education.

CARO-ACRO is a partner with other disciplines in seeking to improve the outcomes of cancer patients, and provides a consultative authority to oncology related agencies, academic institutions and to the public in all matters pertaining to radiotherapy and oncology in Canada.

Currently there are 320 radiation oncologists and 1,190 radiation therapists practicing at 35 centres across the country. CARO-ACRO has a total membership of 687 members from a variety of specialties within the field: radiation oncologists (physicians with specialized training in the care of patients with cancer and the use of radiation treatment), physicists, therapists, radiobiologists, fellows and residents.

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