Image-guided Radiotherapy – A Case Study

a report by
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Curing patients of cancer requires a constant commitment on many levels in a healthcare system. To ensure top-notch patient treatment, St Agnes has invested in the latest technology available. The radiation oncology group complements this sophisticated technology with university-level leadership and experience. This site highlights the latest and greatest in radiation therapies for the treatment of all types of cancers, as well as the people behind the equipment.

Advanced Technology in Cancer Care

Improved cure rates for different types of cancers are the result of advances in surgery, chemotherapy, and radiation therapy. A majority of cancer patients receive radiation therapy as part of their overall course of treatment. Radiation therapy may be in the form of external beam irradiation, using powerful X-ray (electron, photon) machines called linear accelerators, or by placement of radioactive sources inside the tumor, a technique called brachytherapy.

Over the past decade, improvements in computers and networking, radiotherapy treatment planning software, and medical imaging modalities – computerized tomography (CT), magnetic resonance imaging (MRI), ultrasound (US), and positron emission tomography (PET) – have been incorporated into radiotherapy practice. This has lead to the development of 'image-guided radiotherapy' – radiotherapy that uses cross-sectional images of the patient's internal anatomy to better target the radiation dose in the tumor while reducing the radiation exposure of healthy organs. Image guidance leads to improved control of the tumor while simultaneously reducing the potential for acute side effects due to irradiation of healthy tissue surrounding the tumor.

Advanced technologies are currently in use in the St Agnes Cancer Center that enable image-guided radiotherapy treatments. These technologies represent a continuum of advances allowing sophisticated treatments available only in select centers across the nation.

Image-guided Prostate Brachytherapy

Prostate cancer is the most commonly occurring cancer in men today, second only to lung cancer as a cause of cancer-related death in men. The use of the prostate-specific antigen (PSA) test has lead to earlier detection of prostate cancer, resulting in a greater number of candidates for 'prostate brachytherapy', or radioactive seed implantation.

Brachytherapy is the placing of rice-sized, radioactive pellets, or seeds, directly into the prostate using needles guided by realtime transrectal US imaging. The optimal number and location of the seeds are determined in the operating room by the oncologist using specialized treatment planning software. Typically, rows of seeds are deposited uniformly throughout the prostate so that the radiation can cover the entire gland. The metallic seeds emit low-energy radiation that is highly absorbed in the prostate gland close to the seed. With the correct placement of seeds, a very high dose of radiation can be given throughout the prostate gland with little exposure of the healthy tissue and organs surrounding the prostate. Radiation is gradually emitted from the seeds over a period of six to 12 months, after which they become completely inert and can safely remain in the prostate for the rest of the patient's life. The procedure is well-tolerated by most men, with typically no long-term side effects.

Image-guided External Beam Radiotherapy

External beam radiotherapy is the most common form of radiation treatment offered to cancer patients. It consists of irradiating the tumor using high energy X-rays and/or electrons using a machine called a medical linear accelerator. Most treatments consist of multiple X-ray beams pointed at the tumor from different directions. This approach allows more energy to be absorbed in the tumor where the X-ray beams overlap, improving the potential for simultaneously eradicating the tumor and sparing healthy tissue.

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The medical linear accelerators used at the St Agnes Cancer Center are the most advanced treatment machines available in the field today. These machines each have two X-ray beam energies and four to five electron beam energies. This variety of radiation beams is clinically required to provide the most flexibility in optimizing a patient's treatment. The machines also have multileaf collimators (computer controlled radiation beam shaping devices that minimize exposures to healthy tissues) and integrated record-and-verification systems (computer software that monitors the treatment set-up and delivery to improve treatment accuracy). One of the machines is outfitted with an electronic portal imager that allows filmless imaging of the patient set-up prior to treatment.

Integrated Software

A sophisticated treatment planning system is necessary to best utilize the capabilities of these advanced machines. St Agnes Cancer Center's three-dimensional (3-D) treatment planning system is widely recognized as the most advanced treatment planning software tool in the field of radiotherapy today. The system is networked to a variety of imaging systems on the campus, including CT, MRI, and PET. This allows the information from different types of images to be used to better define the tumor volume using a method called image fusion. It is then possible to combine information about tissue function using PET with anatomical information from CT or MRI, a method currently under development in the Cancer Center by Dr Richard Hudes, Director of Radiation Oncology, in collaboration with Dr Ethan Speigler, Director of Nuclear Medicine.

Enhanced Imaging Capability

Most 3-D treatment planning utilizes CT images obtained in another area. Aside from the minor inconvenience to the patient, there are limitations to how a patient can be positioned for a treatment due to the opening, or bore, of a diagnostic CT scanner. To overcome these issues, in 2002, the St Agnes Cancer Center acquired a state-of-the-art, large bore (85cm) helical CT simulator. This was the first device of its kind in the greater Baltimore area, illustrating St Agnes's commitment to advanced cancer care in this community.

The Future of Radiotherapy

The different types of external beam treatments differ mainly in the complexity of treatment planning and treatment delivery. The most complex method of image-guided external beam radiotherapy is called intensity modulated radiotherapy (IMRT). IMRT treatments consist of irradiating the tumor from many (five to nine) beam directions using multiple (three to 10) small field shapes per beam direction, in contrast to conventional radiotherapy treatment where one field shape is used at each of the two to four beam directions typically used. The primary advantage of IMRT over conventional techniques is that it allows exceptional flexibility in treating oddly shaped tumor volumes while simultaneously avoiding healthy tissues. IMRT has primarily been applied to tumors of the brain.

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- Advanced 3-D treatment planning software allows computer-automated optimization of the treatment plan.
- IMRT-enabled computer-controlled treatment unit with a multileaf collimator and electronic portal imager.
- IMRT-enabled record-and-verification system.
- Equipment for verifying the accuracy of the treatment delivery.
- Network integration of the treatment planning system, CT simulator, and the treatment unit.
- Experienced staff to support the IMRT program.

In meeting these technical requirements, St Agnes HealthCare is demonstrating a substantial commitment to advancing the technical capabilities of the center to a level only available in select treatment facilities in the nation. ■