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Radiation Therapy: Past, Present and the Future

The past

The use of ionizing radiation has a venerable history in cancer treatment. Roentgen's 1895 discovery of x-rays was publicized worldwide in January of 1896. The first recorded radiobiology experiment occurred in 1898 when Henri Becquerel developed a skin reaction to a vial of radium kept in his shirt pocket. By the end of that same month, cancer radiotherapy had begun. From 1901, clinical trials with radioactive bodies were undertaken just as Wilhelm Roentgen's discovery of x-rays had given rise to a new cancer treatment: Roentgen therapy. In years after, many doctors pursued studies of various diseases, often using radium samples provided by the Curies: Curie therapy. The results in dermatological diseases and skin cancer were encouraging. Through use of radiation (x-rays and radioactive elements), a new medical field gradually emerged: radiotherapy and in recent years: radiation oncology.

The earliest radiotherapy devices used primitive x-ray tubes to generate very weak radiation not enough to penetrate the body very deeply. Skin cancers were successfully treated in Stockholm as early as 1899. Throughout the 20th century, rapid technological advances led to the development of orthovoltage x-ray therapy machines, and then in rapid succession came cobalt machines that offered higher energy but which delivered relatively slow treatments that lengthened in time as the radioactive source within the machine weakened. Modern radiation therapy traces its origins back to the invention of the "klystron" by brothers Russell and Sigurd Varian in 1937. The linear accelerator was initially used for research in high energy physics in which the klystron accelerates electrons to near the speed of light then these electrons strike a tungsten target causing an emission of x-rays of comparable energies. These high-energy x-ray beams would then be used to bombard a cancerous tumor. The first medical treatment with this method was performed in London; in 1953. The linear accelerator (Linac) is now the accepted workhorse in radiotherapy.

The present

There are over several million cancer survivors now living in the world. They are the true heroes in the war against cancer. Significant advances have taken place in radiotherapy in recent years. The development of computer technology for treatment planning and delivery, late in the 20th century and more recently the availability of advanced linear accelerators with multileaf collimators, capable of independent movement, have transformed the capability of radiotherapy to accurately target localized cancers. A significant factor in the resurgence of radiotherapy is the recently enhanced ability to precisely deliver therapy to the sites of gross disease and to simultaneously reduce irradiation of healthy normal tissues. This has the potential to minimize toxicity while maximizing the chance for disease control. For patients with potentially curable locally or loco regionally advanced disease, conformal three dimensional treatment planning is now routine. For the most complex planning situations, the routine use of intensity modulated radiotherapy (IMRT) facilitates the delivery of therapy to irregular three dimensional shapes. It is fortuitous that one of the major recent advances in the management of cancer has been the rapid progress in molecular imaging with positron emission tomography (PET) and more recently with integrated PET/CT scanners that simultaneously acquire structural and metabolic information. PET scanning provides complementary staging information to CT and can greatly increase the accuracy of disease assessment in a range of common cancers.

The future

Advances in radiotherapy technology, and anatomic and functional imaging together with new insights into tumor biology and new pharmaceuticals are leading to rapid developments in our approach to patients with potentially curable cancers. For the foreseeable future, radiotherapy will remain a critically useful tool in our struggle to control malignant disease. Rapid evolution of targeted therapy is changing the landscape of oncology. Personalized radiation therapy holds the promise that the diagnosis, prevention, and treatment of cancer will be based on individual assessment of risk. Although advances in personalized radiation therapy have been achieved, the biological parameters that define individual radiosensitivity remain unclear. Two novel approaches, DNA end-binding complexes and gene expression classifiers, show promise in solving some of the logistic problems associated with previous assays. Current data suggest that predicting clinical response to radiotherapy is possible. The delivery of this promise depends on the ability to define the variables that define response to clinical radiotherapy. A successful predictive assay is the key to the development of personalized treatment strategies in radiation oncology.

Novel technologies need to be developed that will improve our understanding of the biological variables that define clinical tumor response and will lead to the development of a clinically useful assay. Progress continues in the development of minimally invasive treatments that rely on imaging techniques. Future developments are likely to include an expanding role for minimally invasive treatment, substantial advances in three dimensional computer reconstructions of images obtained with x-rays and other modalities, and the use of computer systems to enhance, store, and display images. Techniques such as ultrasonography and magnetic resonance imaging that do not use ionizing radiation will continue to replace some x-rays procedures. New imaging techniques may include infrared imaging and microwave tomography. In radiotherapy, technological improvements will enable the radiation beam to be confined more precisely to the tumor.

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