Emerging Technology in Cancer Treatment: Radiotherapy Modalities

Review Article [1] | October 01, 2003
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Dr. Hevezi provides a broad overview of the numerous technical innovations that have been commercialized and are now available to many centers for the radiation treatment of cancers. His review describes computed tomography (CT) simulation, stereotactic radiosurgery, intensity-modulated radiotherapy (IMRT), and advances in brachytherapy. The article's breadth of coverage necessarily limits details.

Dr. Hevezi provides a broad overview of the numerous technical innovations that have been commercialized and are now available to many centers for the radiation treatment of cancers. His review describes computed tomography (CT) simulation, stereotactic radiosurgery, intensity-modulated radiotherapy (IMRT), and advances in brachytherapy. The article's breadth of coverage necessarily limits details. Several points alluded to in the article deserve additional comment. The first is the rationale for all of the new technology addressed in the review. This can be stated succinctly as follows: Precise knowledge and control of the three-dimensional dose distribution is essential for a favorable therapeutic outcome. Two primary goals are achieved from this knowledge and control. First, by conforming the dose distribution more closely to the target volume, dose escalation becomes feasible. A higher dose to the tumor could result in an improved probability of local tumor control. Second, by conforming the dose more tightly to the target volume, normal tissues may be spared of radiation, decreasing morbidity. This quest for improved control of the dose distribution has led to advances in photonbeam delivery such as IMRT, and sparked interest in charged-particle beam radiotherapy by several centers, as referenced by Hevezi.

Intensity-Modulated Radiotherapy
IMRT has risen to the forefront of radiotherapy in the past 8 years. As noted by Dr. Hevezi, this computercontrolled irradiation technique provides a new flexibility to the delivery of dose distributions that can have concave geometric characteristics. Besides sparing the anterior rectal wall in the treatment of prostate cancer, as shown in Figure 6 of the article, IMRT has also been used effectively in the treatment of head and neck tumors, where avoiding irradiation of the parotid glands results in less xerostomia compared to conventional treatment techniques. A historical note is in order here: Dr. Hevezi attributes the core idea of IMRT to Mark Carol. In a recent chapter of the lectures of the 2003 American Association of Physicists in Medicine summer school course on IMRT, Steve Webb addresses the history of IMRT.[1] While history is nearly always controversial, most would agree that a key paper by Anders Brahme (1988) laid the theoretical foundation for IMRT.[2] Thomas Bortfeld's thesis in 1990 made an important link between the reconstruction algorithms used in CT image formation and IMRT.[3] Dr. Webb's group provided key insights into multileaf collimation (MLC) sequencing, and Rock Mackie postulated rotational or tomotherapy in 1993.[4] Indeed, the University of Wisconsin holds the patent upon which Nomos technology for IMRT is based. All of this by no means diminishes the importance of Dr. Carol's role in the introduction of the first commercial system to deliver IMRT, in 1992. Finally, in 1994, Art Boyer and Thomas Bortfeld demonstrated the feasibility of delivering IMRT with a MLC.[5] (My apologies to the many others who contributed to the development of IMRT and whose names I have failed to mention.) In contacting some of the primary sources to clarify these points, I was told that this new technology, which has revolutionized radiotherapy, as with many new ideas, was initially viewed with skepticism. Indeed, the need for precise high-tech beam delivery can still spark lively debate.[6] Future Trends
As to the future direction of radiotherapy, Dr. Hevesi has addressed two of the most important trends: multimodality imaging and image guidance. Biologic, functional, and molecular imaging promises accurate spatial localization of disease, which is essential to rationally implementing dose painting-the concept of delivering more dose to subregions of the tumor that show greater tumor proliferative activity. This is necessarily coupled with image-guided therapy, ie, daily imaging to localize the tumor moments before irradiation. The ultrasound device described by Dr. Hevezi and used in the treatment of prostate cancer is exactly such a technology that provides a daily image for
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Published on Physicians Practice (http://www.physicianspractice.com)

precise targeting. **Conclusions**
Finally, how does the specialty of radiation oncology assess which technologies are the most effective? Several of the technologies are expensive, both from a capital equipment and staff viewpoint. Methods to assess the effectiveness and cost-effectiveness of a technology certainly exist[7,8] and should be evaluated. We are fortunate to have the advanced technical resources to improve radiation therapy. Identifying new approaches, and supporting new ideas to control dose delivery will yield additional advances.

**Disclosures:** The author(s) have no significant financial interest or other relationship with the manufacturers of any products or providers of any service mentioned in this article.

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