Everything is changing in oncology and proton therapy

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Abstract

Proton therapy is an evolving force in the future of radiation therapy and cancer management. As the technology becomes more readily available and the cost becomes feasible for smaller centers, proton therapy utilization and indications will become more extensive. Improved planning systems, expanded vendor competition, and diminished proton unit sizes will make proton therapy more available to the greater public. In a world of personalized medicine with increasing use of targeted agents and reduced systemic cytotoxic therapy utilization, proton therapy will be a necessary partner.

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Editorial

Everything is changing......

Everything is changing. Oncology is at the threshold of a new paradigm. For decades, the field of Radiation Oncology has been undergoing technology driven enhancements. From 3-D conformal therapy in the early 1990s to intensity modulated radiation therapy's adoption in the later 90s and later image guided approaches, we have seen improved precision and a continual reduction in dose to surrounding organs. The ALARA principle, as written in the federal registry in 1977 recommends to limit radiation exposure to "As Low As Reasonably Achievable". Radiation therapy delivered with inverse planning, using powerful computers, has allowed for conformality and toxicity reduction unmatched throughout X-ray based radiotherapy's lauded history. Unfortunately, despite advances, radiotherapy still requires unnecessary and undesirable low doses of radiation to uninvolved tissue.

Proton therapy has been long recognized for the physical property of the Bragg peak and for its relatively low entrance dose and absence of exit dose. Historically the technology was extraordinarily expensive with units costing between $100 and 200 million with limited availability due to the cost, massive space requirements, and need for specialized staff. A very large patient pool was necessary to become cost effective. Traditional proton therapy utilized beam scatterers to obtain a treatment capable beam and patient specific compensators and collimators adding to the cumbersome nature of particle therapy. Pencil beam scanning (PBS) proton therapy is a technique developed decades ago at Switzerland's Paul Scherrer Institute that utilizes not only the Bragg peak to deposit dose but the positive charge of the protons to allow the beam to be magnetically scanned layer by layer toward a target. Over the last decade pencil beam scanning techniques and computer enhancements have brought this technique to the pinnacle of radiation oncology. Many new proton therapy centers will utilize only pencil beam scanning approaches. Image guidance, for years a standard component of linear accelerators is now more readily available on proton therapy units. Although traditionally guided by KV-KV photon approaches, on-board cone beam CTs, and in-room diagnostic quality imaging devices will be the standard in the future. The limitations of historic proton radiography are demanding of image guidance to propel the field of proton therapy forward.

Reduced gantry and cyclotron sizes and the decreasing cost of proton units have extended access of this technology from only the largest academic centers into the community at large. In early 2015, two compact proton therapy units were in operation in the United States. The first at Washington University in St. Louis Barnes-Jewish

Hospital utilizes a scattering approach with a mobile cyclotron but has reduced the vault footprint and cost dramatically. The second unit is a pencil beam only scanning system in operation at the Willis-Knighton Cancer Center, a large community hospital, in Shreveport, Louisiana. Their functional operation demonstrates that facilities with limited space or financing may enter the proton community. Each system has reduced the upfront costs to approximately $30 million. At Willis-Knighton, the PBS has allowed for more rapidly planned treatment diminishing the need for expensive patient-specific beam compensators and collimators. Numerous proton therapy vendors now provide options for particle therapy allowing advances in treatment planning, quality assurance, patient immobilization, and dosimetric monitoring.

Compact lower cost proton units offering image guidance and pencil beam scanning (also known as intensity modulated proton therapy) have allowed physicians to expand the indications for proton therapy. Protons are no longer confined to historic indications and are now being evaluated for numerous malignancies of the head and neck, chest, abdomen, and pelvis. By sharing staff and equipment between a compact proton and photon facility at the same location, economies of scale are obtained. Patients may receive a portion of their course with photons and a portion with protons. Trained staff may move freely between modalities with coverage by a single physics and dosimetry team. Imaging and data storage system may be utilized between modalities avoiding unnecessary duplications of services and cost. At Willis-Knighton, the Proteus-One unit will soon have installed an on-board cone beam CT scan which, when combined with PBS inverse planning, will allow up to 25 patients per day to receive particle therapy. Operational for 7 months, time from planning to treatment is typically less than 2 weeks.

Throughout oncology more conservative and toxicity limiting approaches are rapidly becoming the standard. Cancer surgery for genitourinary or gynecologic malignancies is now frequently performed using robotic approaches with quicker recovery times. In medical oncology, precision medicine, using knowledge of unique molecular changes to devise therapeutic strategies specific to a patient have rapidly surpassed cytotoxic therapy as a preferred approach in many malignancies. Future advances in antineoplastic therapy will be based on genetic pathways. It is within this environment that compact proton units, in particular with pencil beam scanning image guided approaches will play an increasing role. Combining modalities with targeted systemic agents and precision proton therapy perhaps even with the addition of immunologic therapy will allow for improved outcomes with reduced acute and chronic side effects. Late treatment induced malignancies are postulated to be reduced with these more conservative approaches and pencil beam scanning proton therapy. As smaller less costly systems flourish, proton technology will extend further into advanced community hospitals and mid-sized academic centers around the United States and the world. At present at least 40 proton therapy sites are either operating, under construction or under development in the United States with no signs of reversal.

Everything is changing in oncology care and proton therapy will be at the forefront of advances in the next generation of radiation oncology. Proton therapy much like IMRT, stereotactic body radiation therapy and brachytherapy will be yet another weapon in the radiation oncologist's armamentarium against cancer.

Conflict of Interest

Dr. Rosen is an Editorial Board Member of Journal of Proton Therapy. Dr. Rosen is an independent stock holder of IBA. The author alone is responsible for the content and writing of this article.