Software toolkit shapes models for personalized radionuclide therapy

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External beam radiation treatment has long been manipulated into the unique shape of patients' tumors for personalized cancer care. Technology providing a means of patient-specific radionuclide drug therapies has not been standardized, as it has been limited to software that requires oncologists to manually define the areas of tumors. A new "phantom" model of the human form that can be deformed and reformed to match anatomy in a matter of hours using 3D graphic design software is being combined with a precision method for predicting how radionuclide therapies interact with tissues to determine the most effective cancer-killing dose for every patient.

"One-size-fits all therapy is not optimal for patients who could be getting personalized cancer treatment," said Susan Kost, MS, principal author of the study from Vanderbilt University in Nashville, Tenn. "With individualized patient modeling we have an opportunity to offer more aggressive radionuclide therapy. Knowing a patient's drug kinetics and anatomy means we can give the maximum dose possible while minimizing effects on normal tissue."

The geometric design technology used for these anthropomorphic models, created by Paul Segars, PhD, at Duke University, is called NURBS (non-uniform rational b-splines). With NURBS, anatomical volumes derived from computed tomography imaging data of patients' organs and body parts are sculpted, rotated and scaled to create a model within one to two hours. Once a model is made, it is used for treatment planning in conjunction with single photon emission computed tomography or positron emission tomography, which—in most cases—use non-therapeutic imaging agents to mimic therapeutic radioactivity in the body. This allows physicians to extrapolate a precise dose, a process called dosimetry, via a 3D map representing projected dose absorption.

Ordinarily, dosimetry is performed by defining the structure and volume of tumors manually in 3D computer programs, known as tumor segmentation. However, this method can be labor intensive and may not provide dose information for normal tissue. In this study, patient-specific NURBS models serve as input in automated dosimetry calculations to factor anatomical data and radiopharmaceutical kinetics for I-131 radioimmunotherapy, specifically looking at the distribution of radioactive particles in the body as they seek out physiological processes of cancer cells and tissues. In action, tumor-tailored monoclonal antibodies are labeled with a potent dose of a radioisotope, and together they bind to receptors on the surface of cancer cells, effectively killing them and sparing nearby healthy cells.

"This research brings nuclear medicine therapy alongside external beam radiation therapy," Kost added. "Now each patient can receive his or her own therapy plan, leading to improved outcomes, better survival rates and less toxicity and harm to normal tissue in the body."

The NURBS phantom models are currently available for clinical use, and Kost expects the modeling toolkit to be used in a subsequent clinical trial conducted by Vanderbilt University for a tumor-targeted peptide receptor radionuclide therapy. A commercially viable version of the dosimetry software is scheduled for release to other cancer centers starting sometime next year.

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