PHYSICS NEWS UPDATE −− Number 738 July 21, 2005 by Phillip F. Schewe, Ben Stein

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TREATING LUNG CANCER WITH 4D PROTONS. Compared to the x rays traditionally used in radiation therapy, protons offer the potential to destroy lung tumors just as competently while inflicting less damage to surrounding healthy tissue. At next week's meeting of the American Association of Physicists in Medicine (AAPM) in Seattle, a research team (including Martijn Engelsman, now at MAASTRO clinic, Netherlands, martijn.engelsman@xxxxxxxxxx) will describe a method for increasing the effectiveness of using protons to treat lung tumors in a small experimental study of four patients.

In traditional radiation therapy, one must use multiple beams of x rays to deliver a uniform dose to a lung tumor; often at least one of the x−ray beams will exit from the healthy (non−tumor−containing) lung and potentially damage it. On the other hand, positively charged, subatomic protons only travel a limited distance through the body; they never make it to the other lung, and they also are more likely to spare nearby organs such as the esophagus and heart. However, the protons' finite range makes their trajectories particularly sensitive to density changes in the lung, caused, for example, by the expansion of the lung during inhalation. For that reason, if the proton treatment is not carefully planned, there is the chance of missing the tumor, thus decreasing the chance of curing the patient. So in planning the treatment of lung cancer patients, the researchers adopted the 4D approach, which is already used in traditional x−ray cancer therapy. In the 4D approach, one takes into account how the patient's breathing moves the lung back and forth over time (the fourth dimension) so that the radiation hits the tumor precisely over all phases of a patient's breathing cycle.

In a study of four patients at Massachusetts General Hospital, the researchers have found that planning and carrying out 4D proton therapy delivers excellent dose levels to lung tumors in all cases. The only thing preventing this technique from wider use is the need to develop an algorithm that cuts down the currently lengthy time it takes to calculate and plan the proton beam's direction and intensity for each breathing phase. The 4D approach is also

applicable to radiation therapy using carbon ions, which is currently being used to help defeat lung cancer in a couple of centers in Japan. (Paper WE−E−J−6C−7; for more information on the meeting; go to http://www.aapm.org/meetings/05AM/)
While currently small, the numbers of proton therapy centers are expected to grow exponentially over the next 20 years; for example, a major proton therapy center is scheduled to open at the University of Texas's M.D. Anderson Cancer Center in Spring 2006.

ELECTRON PARAMAGNETIC RESONANCE IMAGING (EPRI) may become a useful tool for determining crucial oxygen levels in tumors and other biological tissue. Oxygen is central to many diseases; for example, the absence of oxygen makes a cancer cell more resistant to radiation and chemotherapy. Taking advantage of the properties of electrons in certain biochemical compounds, Charles Pelizzari (c−pelizzari@xxxxxxxxxxxx) and his colleagues use a novel technique to form images of the oxygen distribution in small animals with millimeter spatial resolution. In a talk at the AAPM meeting, Pelizzari's group will present EPR oxygen images superimposed on MRI anatomical images of animals. Developing these tools at the Center for In−Vivo EPR Imaging at the University of Chicago, the researchers create these important maps of oxygen levels by magnetically manipulating the unpaired electrons in certain oxygen−containing molecules, including free radicals. Most electrons in atoms and molecules form pairs that mutually cancel out their internal magnetic properties, but unpaired electrons can give the atom/molecule "paramagnetic" properties that cause them to be weakly attracted to an external magnetic field.

Electron paramagnetic resonance imaging (EPRI) obtains pictures of molecules with unpaired electrons in a way that is similar to the way MRI obtains images of atomic nuclei such as the hydrogen in water: an image is formed when paramagnetic molecules, lined up in a magnetic field, absorb and then re−emit electromagnetic waves in or near the microwave portion of the spectrum. Using a series of magnetic fields that vary in strength over a given region of space, these emissions can be reconstructed into a 3D image.
Where EPRI is advantageous over MRI is in providing quantitative images of the distribution of oxygen in living tissues. Pelizzari expects that one day this EPR methodology will obtain submillimeter−resolution maps and also be scaled up to human dimensions. A potential long−term benefit of EPR imaging should be in obtaining both maps of radiation−resistant tumor regions before treatment and in providing quick feedback on the results of cancer therapy in days or even hours, without the use of PET scans which require radioactivity. (Meeting talk WE−D−I−609−8)

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