Bioanatomic Imaging and Treatment Program May 2007
Department of Radiation Oncology, Wake Forest University

Mission

The Bioanatomic Imaging and Treatment (BAIT) Program is a clinical and research program at North Carolina Baptist Hospitals and Wake Forest University School of Medicine. The program, under the direction of J. Daniel Bourland, PhD, was initiated in the late 1990s with a grant from the NCBH Developmental Technologies grant program and industry funding from Varian Medical Systems.

The BAIT mission is to promote and investigate the oncology applications of biological and anatomical imaging (Bioanatomic Imaging). Questions to be answered include:

1. Can tumor biology be imaged?
2. Can image-based tumor biology direct "biologically correct" cancer therapy?

These questions and the potential for bioanatomic imaging and treatment represent a substantial change in approach for much of the oncology community. Bioanatomic imaging tasks include delineation of biological target volumes, use of biophysical modeling, custom radiation dose coverage of target volumes through techniques such as intensity modulated radiation treatment (IMRT), and in general, the quantitative use of bioanatomic images. A collection of multi-modality images that show both anatomy and tumor hypoxia (Figure 1) demonstrates the potential use of bioanatomic imaging for a brain tumor (images acquired through IRB-approved protocol CCCWFU 91A97, JD Bourland, PI). Integration of bioanatomic tissue volumes is shown in Figure 2.

Advanced PET-CT and MR Simulation

BAIT facilities include dedicated PET-CT and 3.0T MR Simulators in the Department of Radiation Oncology in the WFUBMC Outpatient Comprehensive Cancer Center (Figure 3). PET-CT and MR simulations are now being performed using the BAIT simulators:

1. Fluoro-deoxy-glucose (FDG) PET-simulation using the PET-CT simulator is being performed for cancers of the lung, head/neck, and other sites. The entire procedure is performed within Radiation Oncology (Figure 4) including the use of CT-contrast for the acquisition of high quality images.
2. MR-simulation using the high-quality, high-field strength 3.0 T MR simulator is being performed for brain tumor patients and for patients with cancers of other soft tissue regions (prostate, extremity/sarcoma). Other disease sites are in development. The entire MR-simulation procedure is being performed within Radiation Oncology (Figure 5) including the use of MR-contrast for the acquisition of high quality images. Advanced MR imaging techniques, such as MR spectroscopic, diffusion, and perfusion imaging, is being performed to obtain biological images of tumor and normal tissues.

BAIT Clinical and Basic Science Research

BAIT clinical and basic research focuses on the uses of bioanatomic imaging and treatment for patients who have cancer, on understanding the biological mechanisms of cancer as can be seen with imaging, and on radiation treatment responses. Our scientific programs include image-based clinical trials and basic research in imaging science and radiation treatment physics.

Clinical Research

Clinical Trials

The following IRB-approved research protocols are open for patient enrollment and use the BAIT PET-CT and MR simulation devices:

1. A Phase I/II Study of Preoperative Chemoradiation with Oxaliplatin, 5-Fluorouracil / Tarceva and Radiation Followed by Resection and Consolidative Tarcava for Patients with Locally Advanced Cancer of the Esophagus and Gastroesophageal Junction; PET-CT; PI: Blackstock, AW
2. A Pilot Feasibility Study of Hybrid PET-CT Imaging in Patients with Cancer of the Head and Neck treated with Definitive Chemoradiation; PET-CT; PI: Greven, KH.
3. MR and Radiation Treatment for Brain Tumors; MR; PI: Bourland, JD.
4. Hypofractionated Stereotactic Body Radiotherapy; PET-CT; PI: Stieber, VW.
5. BAIT Database; Both PET-CT and MR; PI: Bourland, JD.

Other active clinical trials include national group trials in oncologic imaging (CT, PET-CT, and MR) and advanced radiation treatment (3D-CRT, IMRT) from the ACRIN (American College of Radiology Imaging Network) and RTOG (Radiation Therapy Oncology Group) cooperative groups.

SBES graduate students in the Medical Physics/Imaging tracks have access to these patient image databases and assist in image review for quantitative analyses of multi-modality images obtained in BAIT clinical trials.

Basic Science Research

Medical Physics and Imaging Science Projects

SBES graduate students enrolled in the Medical Physics and Medical Imaging Tracks, Dept of Biomedical Engineering, WFU and VaTech School of Biomedical Engineering and Sciences are working on the following projects in Dr. Bourland's lab:

1. Spatial/contrast resolution in bioanatomic image-based IMRT: A Havnen (2007 graduate, accepted Clinical Physics Residency, University of Chicago)
2. PET-based target delineation for lung cancers: M Lawrence
3. Adaptive radiation treatment: BJ Sintay
4. Small animal stereotactic imaging and irradiation – graduate students assist with the physical aspects of radiation treatment for biology experiments that use the orthovoltage x-ray unit, the linear accelerators, and the Gamma Knife™.

The Department of Radiation Oncology also hosts the TRADONC (Translational Radiation Oncology) post-doctoral research training program. This unique program has six post-doctoral trainees (2 MD radiation oncologists, 2 PhD biologists, and 2 PhD physicists) in an interdisciplinary program that teaches integration of the basic and physical sciences.

Environment and Resources

The Department of Radiation Oncology facility in the Outpatient Comprehensive Cancer Center (Figure 3) includes 55,000 sq ft of clinical space housing the following devices: Four (4) Varian EX-level dual energy linear accelerators (two 6-10 MV and two 6-18 MV) each with 5 electron energies, 120 leaf MLC, aS400 electronic portal imaging (R-arm), and IMRT; Varian Ximatron radiographic/fluoroscopic simulator; GE Healthcare ST-8 PET-CT simulator with 8 slice helical scanning, large FOV fan, CT respiratory gating, flat carbon-fiber table with indexing, CT-based attenuation correction, BGO PET detectors, 2D and 3D PET acquisition, and LAP laser positioning (Figure 4); GE Healthcare TwinSpeed 3.0T MR simulator with Excite HD acquisition, Version 12.0, ancillary 8-channel coils (brain, neurovascular, torso, extremity, flex, and spine), 3D brain MRSI, DTI, DWI, and multi-nuclear (broadband) capabilities, and LAP laser positioning (Figure 5); Five (5) GE Advantage workstations with software tools for virtual simulation, MR and PET image processing, and multi-modality image registration; Elekta Model C Gamma Knife (Figure 6); Varian/Zmed Radiocamera-based linear accelerator radiosurgery; Nucletron Selectron High Dose Rate Remote Afterloader; Nucletron Integrated Brachytherapy Unit (L-arm isocentric R/F imaging); 5 Pinnacle and 2 Eclipse 3D radiation treatment planning systems; and other technology-specific computing systems.

Research facilities include the above clinically-used devices and systems, an XRAD-320 orthovoltage x-ray unit, Clinical Physics Lab with chemical hood, Physics Computing Lab with UNIX/Linux/PC computing systems, radiation detection instrumentation for calibrations and surveys, and office space for graduate students and other trainees.

Faculty and staff personnel include 20 radiation therapists and technologists, two clinical engineers, 1.0 FTE computer systems analyst/programmer, five biomedical engineering and physics graduate students, three post-doctoral trainees, eight faculty radiation oncologists, three faculty radiation biologists and their labs, and eight faculty radiation physicists. Training programs for post-graduates (residents and TRADONC and other post-doctoral fellows), graduate students (MS and PhD), and undergraduates are administered within the Departments of Radiation Oncology, Cancer Biology, Biomedical Engineering, and Physics.

The WFUBMC Bioanatomic Imaging and Treatment Program is directed by J. Daniel Bourland, PhD, Associate Professor and Head, Physics Research and Education, and administered by Kathy Flowers, BSN, RN, Associate Director. Contact information is: BAIT Program, Department of Radiation Oncology, Wake Forest University Baptist Medical Center, Medical Center Blvd, Winston-Salem, NC 27157, Tel: 336-713-6508, Fax: 336-713-6565.
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Figure 1. Bioanatomic Imaging: F18 Misonidazole PET and MRI Spectroscopy. Bioanatomic imaging of localized hypoxia for a brain tumor patient. F-18-fluoromizonidazole PET imaging demonstrating hypoxia (red arrow) and single-voxel MR spectroscopic imaging with a signature suspicious for hypoxia are shown with three MR images for a patient who received surgery and radiation treatment.

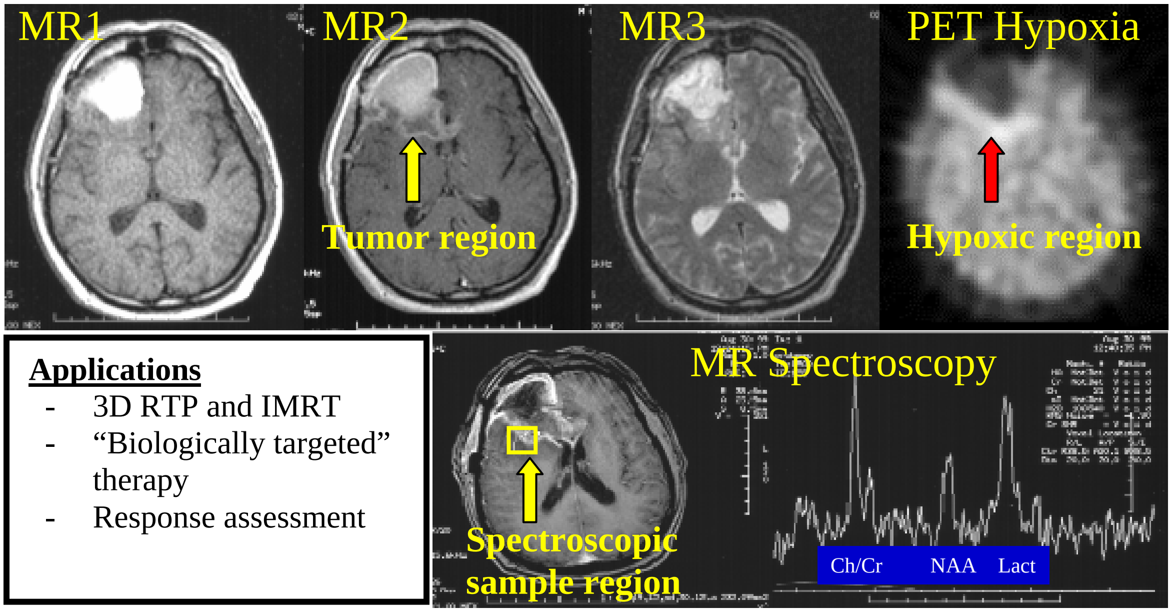

Figure 2. Integration of multiple tissue volumes of relevance for radiation treatment. Tissue volumes from biological and anatomical imaging may include target volumes as well as normal tissues that should be avoided. Ref: Bourland JD, Shaw EG. The evolving role of biological imaging in stereotactic radiosurgery. Tech Cancer Treat Res 2(2):135-140, 2003.

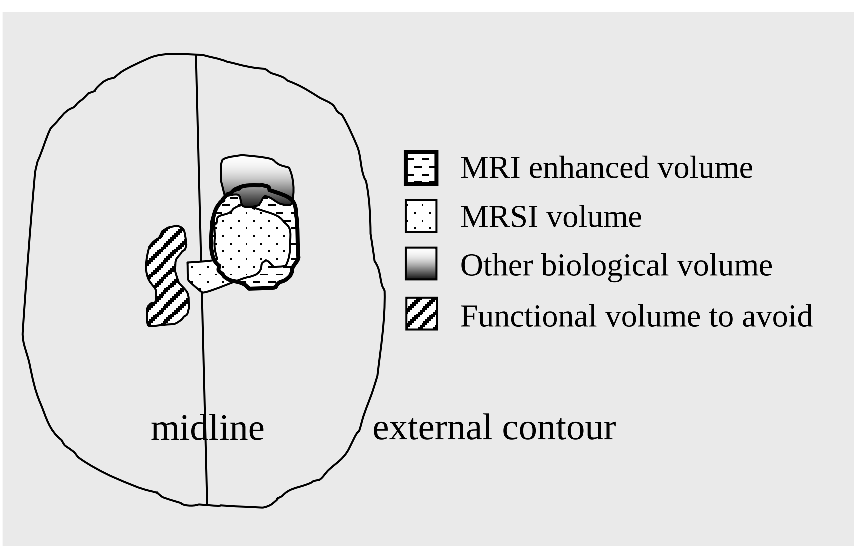

Figure 3. Outpatient Comprehensive Cancer Center. This building is home to the Department of Radiation Oncology, Medical Oncology, Multi-disciplinary oncology clinics, and Outpatient Radiology. Radiation Oncology has approximately 55,000 sq feet of space on the ground floor with state-of-the-art imaging and radiation treatment equipment.

Figure 4: Dedicated PET-CT Simulator, Bioanatomic Imaging and Treatment Program, Department of Radiation Oncology, Wake Forest University Baptist Medical Center, Winston-Salem, NC

Figure 5: Dedicated 3T MR Simulator, Bioanatomic Imaging and Treatment Program, Department of Radiation Oncology, Wake Forest University Baptist Medical Center, Winston-Salem, NC

Figure 6: Leksell Gamma Knife™, Department of Radiation Oncology, Wake Forest University Baptist Medical Center, Winston-Salem, NC. The Gamma Knife™ clinical program is one of the top five programs in the US based on numbers of patients treated. The device is also used for brain tumor and neuron-science basic research for irradiations of small animals (inset).