Magnetic Resonance Imaging and Spectroscopy are extremely flexible methods which evaluate tumor anatomy, physiology, and metabolism non-invasively, and with good spatial resolution. Because of its excellent soft tissue contrast, MRI has been widely used since its inception for identifying tumors and defining tumor margins. With rapid improvements in anatomic imaging, functional information regarding tumor proliferation is available from MR. For example, cancer invasion of the prostate capsule can often be detected, and is a reliable marker for highly malignant tumors. New contrast agents are available which may make it possible to identify tumor infiltration of normal tissue with great accuracy.

MR is extremely useful for evaluating tumor blood supply. This is important because angiogenesis is an important marker for malignant tumors. Most hemodynamic measurements in tumors rely on the use of MR contrast agents. High molecular weight blood pool agents report tumor blood volume – and thus microvessel density, as well as capillary permeability. Volumetric blood flow can also be measured with these large molecules, but low molecular weight highly permeable contrast agents are often better suited for this application. Non-invasive methods which do not require tracers , such as 'diffusion weighted images' can be used to infer microvessel flow, as well as other aspects of hydrodynamics in tumors. A variety of targeted contrast agents are being developed are designed to target receptors on blood vessel walls, to provide markers for angiogenesis.

Measurements of oxygen level are extremely important for characterizing tumors and their response to therapy. Fluorine-19 MR and Electron Spin resonance can be used to measure oxygen levels quantitatively, following injection of oxygen sensitive tracers. Gradient echo images are sensitive to changes in blood oxygenation, due to the paramagnetism of deoxyhemoglobin (i.e. the BOLD effect); this approach has very high spatial resolution and does not require injection of tracers, but is not very quantitative.

A variety of MR methods are used to image metabolic processes such as oxidative phosphorylation, glycolysis, pH, and ion fluxes. These methods include proton and phosphorous MR spectroscopy and use of a variety of probe molecules. Dr. Gillies has done outstanding work in this area and his presentation will focus on some of these issues.

MR is likely to play an increasing role in cancer diagnosis and treatment planning. Several areas where there is tremendous growth in clinical application of MR to oncology are:
1. Early identification and staging of breast and prostate cancer.
2. Monitoring changes in hemodynamics during therapy.
3. Use of MR spectroscopy to stage cancer.

It is extremely important to minimize cost of MR exams. A challenge for MR physicists in the next few years will be decreasing the duration of MR exams while at the same time increasing information content. In addition, the development of hardware and software which facilitate inexpensive low field MR scans will be of great importance.

Educational Objectives

1. Provide overview of MR methods
2. Review current and future applications of MR to cancer diagnosis and treatment