NEUROtransmitter

A PUBLICATION OF SANTA BARBARA NEUROSCIENCE INSTITUTE AT COTTAGE HEALTH

SPRING 2016

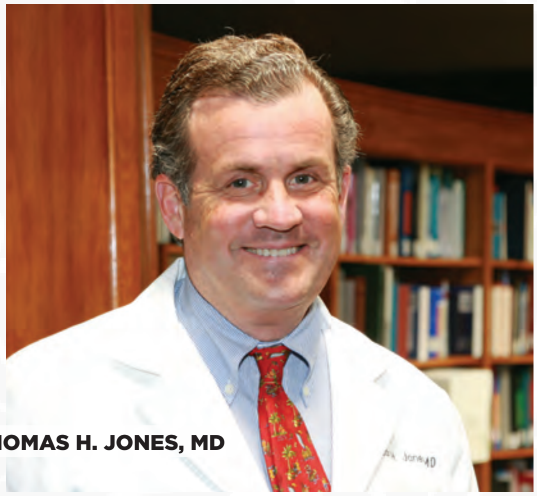
Brain Tumor Surgery Using Intraoperative MRI (iMRI)

Cottage Health

Dear Colleagues,

THE YEAR 2016 is full of excitement in the neuroscience arena at Santa Barbara Cottage Hospital. After years of planning and preparation, the "OR Triad" of rooms for the advanced practice of neurosurgery has opened.

This OR suite contains three connected rooms. In the first room is a 21st century, state-of-the-art operating theatre which contains multiple video arrays not only connected to the hospital's radiology DR system but also to the EMR and the operating microscopes. Brain Lab software has enabled the room to take full advantage of the latest in stereotactic navigation inside the brain or spine.



THOMAS H. JONES, MD

The 3T Siemens large bore intra-operative MRI (iMRI) is situated in the middle room and allows patients, under anesthesia, to be moved from either adjacent room for real-time re-imaging of their neuroanatomy to allow more accurate, safe and complete resection of their brain tumors or management of patients with acute strokes and other vascular lesions. Eventually this iMRI room will allow some procedures to be done in the bore of the magnet, permitting real-time accurate localization of brain probes. Examples of such procedures would initially include functional brain surgery for Parkinson's disease, percutaneous treatment of certain movement disorders, epilepsy surgery and brain biopsies.

The third room contains the Neuro/Vascular space which houses the Siemens Zeego robotic high resolution imaging device, already being used by the vascular neurosurgeon and the general vascular surgeons.

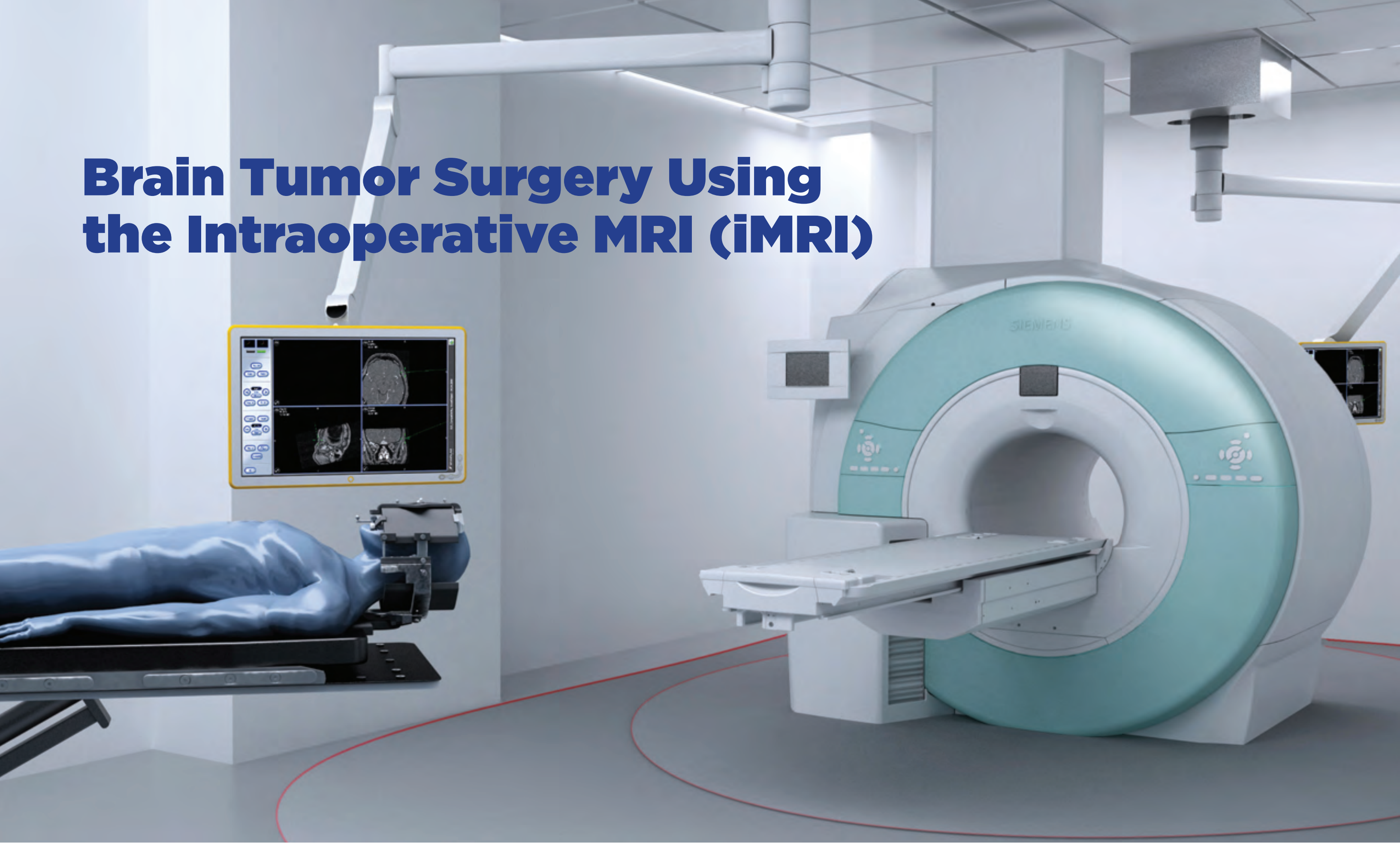
I am told that no other hospital on the West Coast has this combination of technologies available to them in their operating rooms. Fortunately, we prepared for this day long ago by recruiting world-class, experienced neurosurgery sub-specialists who can instantly deliver even better care using these tools.

The successful completion of this endeavor was truly a team effort including SBCH administration, nurses, surgeons and, of course, donors. I am also reminded that the building and engineering feat to put these three rooms together was far more complex than building any of the new hospital. I therefore give thanks to the engineers, architects and laborers who made this happen.

If you would like to get a flavor of the buildout complexities, you may visit the Cottage Health You Tube channel and the video titled "iMRI arrives at Santa Barbara Cottage Hospital."

Sincerely,

THOMAS H. JONES, MD
Neurosurgeon and Medical Director
Santa Barbara Neuroscience Institute at Cottage Health



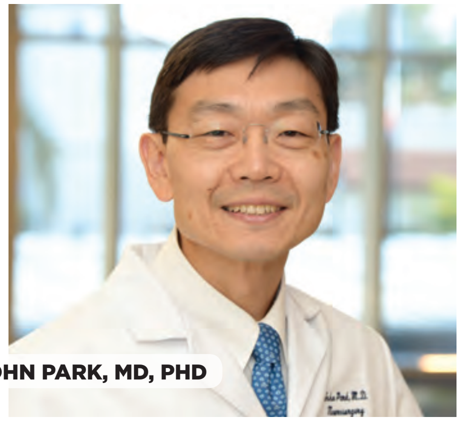
Brain Tumor Surgery Using the Intraoperative MRI (iMRI)

BY JOHN PARK, MD, PHD, Brain Tumor Neurosurgeon and Medical Director of the Brain and Spinal Tumor Program at the Santa Barbara Neuroscience Institute at Cottage Health

There is a growing consensus that, for most types of brain tumors, a patient will survive longer if all, or nearly all, of the tumor is surgically resected. The maximal safe resection of a brain tumor is dependent on the ability of the neurosurgeon to locate the tumor within the brain and distinguish it visually and tactilely from normal peritumoral brain tissue.

The removal of surrounding normal tissue must be avoided to minimize the initiation or exacerbation of new or pre-existing neurologic deficits, respectively. Preoperative magnetic resonance imaging (MRI) produces two-dimensional (2-D) images of the brain that can be used to determine the relative location, size and shape of a tumor and is extremely helpful in pre-surgical planning.

Stereotactic neuronavigation is a commonly used technology that digitally co-registers a patient's visible scalp and facial features to a virtual three-dimensional (3-D) model of the head and brain generated using preoperative MRI data. The 3-D model and the corresponding 2-D sections through it are viewed on a video monitor during surgery. Similarly co-registered surgical instruments that are visible in real space are simultaneously shown in virtual form in spatially accurate relation to the 3-D and 2-D head and brain images displayed on the video monitor. In other words, a surgical probe placed on the scalp or within the brain is displayed on a video screen as a virtual probe within a preoperative MRI-based 3-D model of the head *(Figure 1)*.



JOHN PARK, MD, PHD

Using this technology, a surgeon is able to point to a region of otherwise homogeneous-looking brain tissue and identify areas such as tumor margins that are readily visible and easily distinguishable on MRI. The chances of resecting all or most of a tumor are greatly maximized when its margins can be clearly identified.

Inaccuracies Produced by "Brain Shift"

The major shortcoming of stereotactic neuronavigation is the movement of brain tissue that occurs after a burr hole

Santa Barbara Cottage Hospital opened the first 3.0 Tesla iMRI in California in February 2016. The neurosurgeons utilizing the iMRI are among the world's most experienced users of this technology.

or craniotomy bone flap is made, following the partial resection of a tumor or the draining of a nearby cyst or ventricle. Commonly referred to as "brain shift," this tissue movement can lead to a significant change in the actual shape and margins of a tumor and render the preoperative MRI-based 3-D model used by the stereotactic neuronavigation system inaccurate *(Figure 2)*.

One solution to overcoming the inaccuracies introduced by brain shift is to acquire new MRI data during surgery, after the brain shift has occurred, and update the 3-D model and 2-D images accordingly. The intraoperative MRI (iMRI) was initially developed for this purpose.

The world's first iMRI was developed by General Electric and installed at Brigham and Women's Hospital in Boston in 1994. It was a 0.5 Tesla system that featured two vertically oriented superconducting magnets with sufficient space in between the "double donuts" for the patient's head and the neurosurgeon. Using non-ferromagnetic instruments and MRI-compatible anesthesia ventilators and patient monitoring equipment, surgery was performed within the magnetic field. Imaging also could be performed in real time without the need to remove the patient from within the magnet. The shortcomings of this pioneering system included the relatively low field strength of the magnet and the resulting lower-quality images compared to those obtained using 1.5 and 3.0 Tesla diagnostic scanners; the limited availability of MRI-compatible instruments and ancillary equipment such as microscopes; and restrictions on the positioning of patients during surgery. In response to these limitations, subsequent iMRI systems were developed in which surgery is performed in a standard operating room environment with ferromagnetic instruments and equipment and either the patient is transported into a fixed iMRI scanner in an adjacent room or a portable iMRI scanner is moved into the operating room after the removal of ferromagnetic objects.

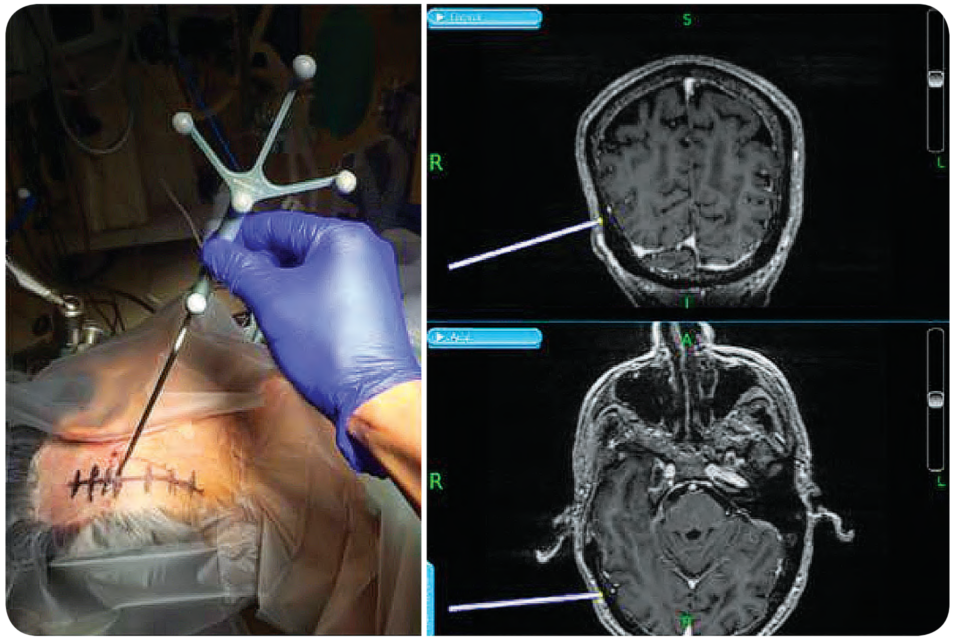


Figure 1: In the left panel, a stereotactic navigation probe has been placed on the scalp prior to prepping and sterile draping. In the top and bottom right panels, a virtual probe is shown on a preoperative MRI-based 3-D model of the head.

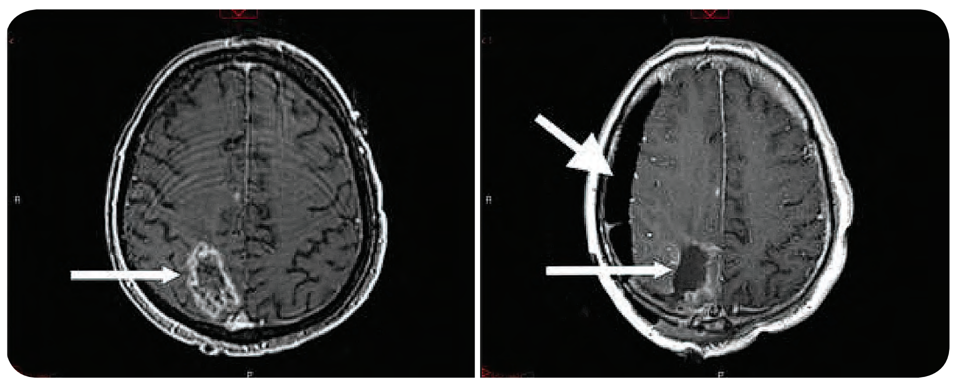


Figure 2: In the left panel, the arrow identifies the tumor on a PRE-operative, T1 weighted, contrast enhanced axial MR image. In the right panel, the similar arrow identifies the resection cavity on an INTRA-operative, T1 weighted, contrast enhanced axial MR image. Also in the right panel, the larger arrow indicates the presence of intracranial air in the subdural space. As can be seen by comparing the left and right panels, the brain has shifted due to the craniotomy and the resection of tumor.

Use of iMRI to Improve Patient Outcomes

The iMRI has been used to improve patient outcomes in a variety of tumor types including low- and high-grade gliomas. In a retrospective study of 156 patients who underwent surgical resection of a unifocal, supratentorial, low-grade glioma in an iMRI suite, the 1-year, 2-year, and 5-year age-adjusted and histologic-adjusted death rates were 1.9 percent, 3.6 percent, and 17.6 percent, respectively. These rates are significantly lower than the

Continued on page 11