

Neurosurgery for Brain Tumors: Same Goal, New Technology

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Introduction. The role of the neurosurgeon in the optimal management of a patient with a central nervous system (CNS) tumor has evolved in some ways, particularly the new standard of being a member of a multidisciplinary neuro-oncology team. This team includes other neurosurgeons as well as neuro-oncologists, radiation oncologists, neuroradiologists, neuropsychologists, nurses, social workers and other professionals who meet regularly to insure a team approach to patient management. However, there has been no change in the principle mandate and responsibility of the surgical neuro-oncologist, to remove the tumor. What has changed is how this is achieved more safely and more often. This article will address these improvements and explain the technology that has facilitated this progress.

Neuroimaging. First, and perhaps most important, are the continuing advances in neuroimaging, which allow neurosurgeons to better understand what the full extent and location of the tumor is. For example, most high-grade CNS tumors consist radiographically of an area of bright signal

following an injection of the agent gadolinium (gadolinium enhancement) surrounded by an area, often much larger, of abnormal signal that is not enhanced by gadolinium (T2 signal). This area can be tumor, swelling, or both, but standard MRI scanning cannot distinguish between them. Newer scanning techniques such as MR spectroscopy or PET scanning with dopa (investigational) frequently can determine whether there is tumor in the nonenhanced area and where the likely edge of grossly detectable tumor is located. This knowledge can lead to the removal of tumor which otherwise would have been left behind to bedevil the patient in the future. We have seen cases where patients came to us for consultation from another center where they had undergone what appeared to be an adequate (gross total) resection of their tumor only to discover through MR spectroscopy that a substantial volume of resectable tumor had been left behind. In many cases, it was possible, subsequently, to remove much or all of this residual disease without any harm to the patient.

Another issue we often encounter in our desire to optimize tumor removal is the

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functional outcome for the patient. Many tumors, unfortunately, are located in areas of eloquent brain where tumor removal might result in devastating deficits such as aphasia and/or hemiplegia. Technology, largely developed from epilepsy surgery, now allows us to better define the relationship between tumors and areas of eloquent functional brain.

For example, functional MRI (fMRI) is a technique whereby an MRI scan can be modified to reveal areas of motor and more recently sensory and language functions situated on the cortex. Currently, we are able to use fMRI at Swedish Medical Center for localization of the primary motor cortex. Patients are asked to tap their finger repetitively during an MRI scan which results in visibly detectable change in cerebral blood flow and in the area of cortex where the primary motor neurons are located. The neurosurgeon can then determine if removal of the tumor will or will not leave the patient with a major deficit. This can help the neurosurgeon in planning an approach which will minimize risk of injury.

Another important test, frequently used in our own Program, is the Wada test in which selected injection of the short-acting anesthetic, sodium amytal, sequentially into each carotid artery allows the definitive determination of which side of the brain is dominant for both language and memory. The neurosurgeon then decides if it is necessary or not to map the precise location of language on the side where the tumor is located. Mapping of language can be accomplished either preoperatively by surgically placing a grid of electrodes on the surface of the brain on the dominant side, returning the patient to the floor, and subsequently using the grid to electrically stimulate areas of brain during speech to

determine which areas are responsible for the speech. Patients may also be awakened during the surgery itself, without discomfort, and repetitively tested by the neurologist and/or neuropsychologist as the operation proceeds in order to inform the neurosurgeon if speech is being affected and thus greatly facilitate the safety of the surgery.

Thus, a combination of greatly improved neuroimaging and the ability to determine where eloquent functions are located in relationship to tumors can allow a much greater likelihood of achieving the goal which is so critical to the chances of long-term survival, the complete and safe removal of all grossly detectable tumor.

Adjuvant Treatments. Despite these advances, it is well known that all malignant CNS tumors invade the brain microscopically and cannot be cured by surgery alone; there is always microscopic disease left behind. Most of the microscopic disease is located within one inch of the edge of the surgical cavity. Recent research has focused on strategies to eradicate this residual disease where 90 percent of all recurrences occur. These approaches include two techniques now available in our Program, photodynamic therapy (PDT), and Gliosite.

Photodynamic Therapy. PDT is a technique in which a light sensitive chemical (photophryn) is given to the patient intravenously 24 hours before surgery in order to allow its selective uptake by tumor cells. After removal of the tumor, a laser light source is placed into the surgical cavity. This intense light penetrates 1 to 2 cm into the surrounding brain and converts photophryn into a poison which can destroy the tumor cells but is minimally toxic to normal brain cells. A federally funded investigational trial

of this treatment is currently active in our Center.

Gliasite. A second technique, Gliasite, allows the placement of a balloon into the surgical cavity following tumor removal which conforms to the shape of the cavity. This balloon is connected to a reservoir which is left under the scalp. Following sufficient time for recovery from surgery, a radioisotope (I^{125}) is injected into the balloon and left there for long enough to provide an effective dose of radiation therapy to the margins of the cavity where most of the residual tumor is located.

Despite these newer techniques, and despite better tumor removal up front, and despite better postsurgical treatment such as radiation, chemotherapy and biological therapy, most patients ultimately relapse. In the past, these patients were essentially abandoned medically and died rapidly. Most recently, for patients with good residual neurological function and quality of life, we have offered re-operation followed by newer postsurgical treatments. Although this is not always beneficial, many patients have had significant benefit in extension of survival and quality of life; a few have had long-term survival and might be considered cured. This approach is not unique to our Program, but is used much less commonly in most other centers.

Conclusion. The role of the surgical neuro-oncologist (neurosurgeon) in the management of patients with CNS tumors remains crucial to the prospects of these patients for longer and better survival. The neurosurgeon's role, principally to remove the tumor, is greatly expedited by the development of new technologies to identify the true extent and location of the tumor and

its relationship to critical areas of normal brain. In addition, the neurosurgeon is able to offer patients new techniques to attack tumor cells which persist beyond the surgical margin. Finally, surgery for recurrent tumors, with or without adjuvant treatment such as photodynamic therapy, has made an impact. As technology continues to develop, we expect that an increasing number of patients will benefit from surgical outcomes which open the door for longer and better survival and, for some, cure.

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