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Clinical outcomes from maximum-safe resection of primary and metastatic brain tumors using awake craniotomy

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ABSTRACT

Objective: To retrospectively analyze outcomes in patients undergoing awake craniotomies for tumor resection at our institution in terms of extent of resection, functional preservation and length of hospital stay.

Patients and methods: All cases of adults undergoing awake-craniotomy from September 2012–February 2015 were retrospectively reviewed based on an IRB approved protocol. Information regarding patient age, sex, cancer type, procedure type, location, hospital stay, extent of resection, and postoperative complications was extracted.

Results: 76 patient charts were analyzed. Resected cancer types included metastasis to the brain (41%), glioblastoma (34%), WHO grade III anaplastic astrocytoma (18%), WHO grade II glioma (4%), WHO grade I glioma (1%), and meningioma (1%). Over a half of procedures were performed in the frontal lobes, followed by temporal, and occipital locations. The most common indication was for motor cortex and primary somatosensory area lesions followed by speech. Extent of resection was gross total for 59% patients, near-gross total for 34%, and subtotal for 7%. Average hospital stay for the cohort was 1.7 days with 75% of patients staying at the hospital for only 24 h or less post surgery. In the postoperative period, 67% of patients experienced improvement in neurological status, 21% of patients experienced no change, 7% experienced transient neurological deficits, which resolved within two months post op, 1% experienced transient speech deficit, and 3% experienced permanent weakness.

Conclusions: In a consecutive series of 76 patients undergoing maximum-safe resection for primary and metastatic brain tumors, awake-craniotomy was associated with a short hospital stay and low postoperative complications rate.

1. Introduction

Brain tumors impose a significant disease burden with the incidence of primary brain cancer of 40.1 per 100,000 of adult population [1]. Surgical resection is a central modality in the management of brain tumors. Accordingly, the extent of surgical resection can significantly impact survival. For instance, in patients with low and high-grade gliomas, the extent of resection has been well correlated with survival in the literature [2–4]. Moreover, the extent of resection is accepted as one of the most important factors correlating with overall survival, progression-free survival, and malignant transformation in low-grade gliomas [5,6].

Ultimately preservation of neurological function is a paramount objective of surgical resection. In particular, prevention of neurological deficits and preservation of quality of life is crucial for low-grade gliomas (WHO grade I–II) due to prolonged survival of a substantial portion of these patients, 25% of 20-years-survival post diagnosis [7]. Not surprisingly, tumors involving or adjacent to critical areas controlling motor and speech function present an additional challenge to the extent of surgical resection. Therefore resection strategies that permit interrogative correlation between surgical anatomy and neurological function are very critical for functional preservation.

Abbreviations: MRI, magnetic resonance imaging; WHO, World Health Organization

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Awake craniotomies minimize the potential for significant long-term neurological deficits [8–10]. Unlike craniotomy performed under general anesthesia, awake craniotomy allows for conscious interrogation by direct stimulation of the brain tissues to ascertain areas of function for protection before and during resection. This delineation of brain maps using real-time function assessment accounts for the improvement of surgery outcomes, namely decrease of residual tumor volumes and decrease of neurological deficits in awake procedures [11,12]. One meta-analysis of 90 reports of intraoperative stimulation mapping estimates decrease of intraoperative mortality and improved extent of extent of resection by 17% [13]. Awake-craniotomies are often been associated with great functional outcomes due to superior extent of resection in eloquent areas as compared to standard methods under general anesthesia [12,14,15]. Further, awake procedures carry additional benefits over traditional surgeries with general anesthesia. One recent meta-analysis study of 951 patients including 411 patients who underwent awake-craniotomy and 540 standard craniotomy reported much shorter hospital stays and quick functional recovery for the patients who underwent awake craniotomy [16]. Awake procedures allow for considerable reduction of overall duration of hospitalization by minimizing intensive care time [17]. Shorter hospital stays with awake craniotomy translate into decrease in hospital expenses [18].

Although awake craniotomies have been routinely utilized for resection of primary brain tumors within or adjacent to eloquent areas, the application of such strategy for metastatic cancers is limited. Surgery is also an important adjunct treatment in brain metastasis. Extracranial disease progression is most common cause of death of patients with brain metastasis; however, those with uncontrolled brain metastasis more likely to die of neurological causes [19]. Therefore, surgical treatment is important in gaining control of disease, relieve the symptoms caused by the mass effect of the tumor, edema, or hydrocephalus, and improve tolerance to adjuvant therapy especially in bulky tumors (> 3 cm) [20,21]. Currently, use of awake procedure for resection of metastatic brain cancer is very limited. A study by Gupta et al. report favorable outcomes in a study of 58 patients, only one of those patients had a metastatic lung lesion [22].

At our comprehensive cancer center, we encounter patients with primary and metastatic cancers requiring surgical resection. Since these patients require adjunctive therapies such as chemotherapy and radiotherapy as well as clinical trials, there was an impetus for maximum-safe resection with the goal of functional preservation. We instituted a routine awake resection program with the goals of maximizing resections, while minimizing deficits and decreasing the overall hospital stay. Therefore, the objective of this study was to the above outcomes of awake craniotomies in our series of 76 consecutive cases of awake craniotomies for metastatic and primary brain tumors.

2. Patients and methods

We designed a retrospective cohort study. Chart review has been conducted for all cases of adults undergoing awake craniotomy at our institution from September 2012 to February 2015 based on protocol approved by institutional review board. Patients with lesions proximal or involving eloquent areas were considered for awake craniotomy with strict selection criteria further described. We defined the zones of eloquence to include dominant temporal, supramarginal, and angular gyri; dominant and nondominant supplementary motor area, internal capsule, deep grey nuclei; primary sensory-motor cortices and posterior part of the frontal lobes (< 2 cm from precentral sulcus). Preoperative diagnosis was established based on the presentation, history, and preoperative MRI. As a large oncologic center we do not routinely perform biopsy prior to the resection as we have high volume of patients with brain cancers, the facility, and skilled team to complete tumor confirmation and resection at the index operation. Pre-operatively, patients underwent functional magnetic resonance imaging (MRI) and fiber tractography to define relationship between the tumor and functional cortex and stereotactic navigation intraoperatively. Patients with sleep apnea, potential intubation difficulty, increased intracranial pressure, history of postanaesthesia nausea and vomiting, bleeding diasthesis, seizures, and anxiety were not deemed suitable candidates for awake craniotomy. Patients without excluding conditions, amendable to the procedure, and able to cooperate during the operation were finally selected by surgeon and the anesthesiologist. All patients had a supratentorial lesion. Patients undergoing Ommaya port placement or biopsy were excluded from this study due to the nature of this focusing on outcomes of craniotomy for tumor resection. Pathology of the surgical sample was determined by a neuro-pathologist according World Health Organization criteria. Information regarding patient age at surgery, sex, cancer histology, procedure type, location, surgery duration, intra-operative events, post-operative course, duration of hospital stay, extent of resection, and postoperative complications was evaluated.

Tumor location, according to hemisphere and lobe involvement, was determined based on MRI images obtained and reviewed for each patient: frontal, parietal, temporal, occipital, frontoparietal, frontotemporal, and temporoparietal. Proximity and involvement of functional cortex have been also recorded: motor, sensory, speech, and motor/sensory.

Patient outcomes were determined in terms of extent of resection, duration of hospital stay, and postoperative complications including wound infections, hemorrhage, neurological deficits, and seizures. The extent of tumor resection was based on a postoperative MRI performed within 48 h after surgery by a neuro-radiologist who characterized the resections as gross total, near-gross total, or partial. Tumor resection was considered total if there was no residual signal abnormality, near total if > 95% of the tumor has been removed, or partial if more 5% of residual tumor is identified. Postoperative mortality and complications were recorded if occurred within 30 days after the surgery. Neurological deficits after the surgery were determined based on pre-procedure neurological status and were designated as improved, unchanged, and worsened. For any patients with worsened neurological status, neurological deficits were deemed transient if resolved within 2 months after the surgery, otherwise deemed persistent.

2.1. Surgical technique

Patients underwent high-resolution MRI for intraoperative navigation (Brainlab, AG, Munich, Germany). In patients with tumors near or involving motor, sensory, or eloquent areas, diffusion tensor imaging (DTI) as well as blood oxygenation level dependent (BOLD) functional MRI was obtained to delineate fiber tracking of the motor pathways as well as associated speech pathways.

On the morning of surgery, the surgical, anesthesiology, and nursing team met the patients. Once the anesthesiologist evaluated the patient to be a suitable candidate for an awake technique, preparation was made for a scalp block and gentle sedation (Monitored Anesthesia Care MAC). Once the patient was in the Operating Room and American Society of Anesthesiology standard monitors were placed, sedation was started consisting of Dexmedetomidine and Remifentanil. Patients typically underwent a cranial scalp block with bupivacaine and epinephrine. In addition, conscious sedation in the form of Dexmedetomidine and Remifentanil was employed as needed. All patients were given routine prophylactic vancomycin and gentamycin antibiotics intravenously, unless contraindicated, along with corticosteroids and anti-convulsants. Patients were positioned either supine or supine-lateral depending on tumor location, and the head was immobilized in three-pin head clamp Mayfield system. Surgical sites were prepped and draped in sterile fashion. Draping of the surgical field was done strategically in order to ensure immediate and full access to the airway, motor/speech testing, and to minimize rebreathing of carbon dioxide.