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Minimally invasive key-hole approach for the surgical treatment of single and multiple brain metastases

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ABSTRACT

The role of surgical management in the setting of multiple brain metastases is controversial. Although the role of surgical resection in single brain metastases is well stated, in multiple brain metastases whole brain radiation therapy remains a mainstay of treatment. In this series, the authors evaluate the efficacy of minimally invasive neurosurgical techniques in the resection of brain metastases with a particular focus on multiple metastases.

57 patients who underwent surgical resection of brain metastases with a key-hole approach, were analyzed for surgical success, complications, neurological deficits, functional outcome and overall survival. 187 brain metastases were detected. The majority of patients improved in KPS postoperatively at 6 weeks (80.6%) and 3 months follow up (62.5%). Mean overall survival was 14.2 months with a 1 year survival rate of 44%. According to univariate analysis, poor systemic control of cancer, tumor extending to both lobar and deep brain, lower extent of resection and symptomatic tumor resection were found to be associated with poorer survival. With the use of minimally invasive neurosurgery, aggressive management of multiple metastases leads to minimal postoperative stay, improvement in quality of life and overall survival. Patient overall survival is dependent on recursive partitioning analysis (RPA) class, and should be used to guide management.

1. Introduction

Brain metastasis was once considered the most challenging and discouraging diagnoses in neurosurgery. Depending on factors such as functional status, extent of systemic disease, age and number of metastases, median survival time ranges from 2.3 to 13.5 months [1]. Until the early 1990s, the role of surgery in the treatment of brain metastases was considered controversial.

In the last decade, several prospective studies established the value of combined surgical resection and radiation therapy for brain metastases. Surgical resection therefore became an acceptable standard therapeutic option for surgically accessible solitary brain metastases [2–5]. The role of surgery in multiple metastases is still controversial due to the variable nature of the systemic cancer and its metastatic disease. Many treatment algorithms exist regarding surgery in the treatment of multiple metastases, and they all fit on a spectrum from least aggressive to most aggressive [6].

In patients with more than three brain metastases WBRT with hypo-fractionated regimens is the treatment of choice and is purely palliative [7]. Kondziolka et al. [6] suggest that surgical resection remains important for the removal of large symptomatic metastases: surgery is performed on patients with multiple brain metastases who have one life threatening lesion. Radiosurgery for small or inaccessible lesions combined with surgery for larger or symptomatic lesions may represent an effective approach to the patient with multiple brain metastases [6].

In patients with up to three brain metastases, good performance status (KPS > 70) and controlled systemic disease, surgical resection is an option when the lesions are in accessible locations [8]. Advances in surgical management (MRI, neuronavigation, microneurosurgery and endoscopic assisted neurosurgery) indicate that the role of minimally invasive surgery in the setting of multiple metastases needs to be reviewed.

2. Materials and methods

2.1. Data collection

After institutional ethics approval, information was gathered from patients' files, hospital records and medical imaging reports.

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Between November 2000 and November 2008, 57 patients were identified with either single or multiple metastases that underwent 72 surgeries at the Centre for Minimally Invasive Neurosurgery, Sydney. All operations were performed by the senior neurosurgeon (CT). Statistical analysis was performed using the SPSS 17 software package.

2.2. Surgical technique

All operations were performed under general anaesthesia with normothermia and slight hypocapnia. Patients were positioned according to the site of lesion, and retractors were not used in any case to avoid localized brain ischemia and contusions. Intraoperative neuronavigation (BrainLab, Feldkirchen, Germany) was used to localize symptomatic tumors and allowed for smaller craniotomy and skin incision.

If the tumor was not all clearly visible with the microscope alone, the endoscope was used to control the remaining tumor and removal was performed under endoscopic control. Endoscopic guidance was used during 9 procedures to ensure complete tumor resection, when the tumor extended into the ventricular system, and when there was a disparity in perceived tumor margins between macroscopic judgement and frameless stereotaxis. Endoscope assistance was used to assess the competency of removal at the end of the procedure and visualize the tumor bed, showing tissue color and reaction to manipulation with direct and curved suction.

All patients had a postoperative MRI within 48 h to determine the extent of resection. MR images were compared to the preoperative study by an independent radiologist and neurosurgeon not involved in surgery, and resection was graded based on a T1 MRI scan with contrast.

Neurologic examination was performed before discharge, with a clinical and radiological follow up at 6 weeks, 3 months and 12 months postoperatively. Clinical status of the patient was noted and recorded using Karnofsky's Performance Status (KPS) at all consultations. The patient follow up period ranged from 3 months to 4 years (mean 11.51 months).

2.3. Outcome evaluations

Operative death was defined as death within 30 days after surgery. All complications during this period to follow up (6 weeks) were also evaluated. Complications such as weakness, sensory deficits, visual or speech disturbances were classified as neurological complications. KPS score was evaluated before surgery and at 3 and 12 months follow up. Survival time was measured in months from the date of the patient's first craniotomy to the date of death or last follow up.

In order to optimize management, the Radiation Therapy Oncology Group (RTOG) USA has used recursive partition analysis (RPA) of patients with brain metastases to identify three subgroups of patients with significantly different prognoses which can be used to guide optimal management decision making (RPA class I, II, III) [3,9]. We analyzed patients according to the recursive partitioning analysis (RPA) classification set forth by the RTOG. Survival analysis was based on patients followed up through to November 2009. Survival curves and MSTs were calculated with the nonparametric Kaplan–Meier method.

Comparisons of survival times and assessment of the strength of association among MSTs and each of the variables were performed with log-rank analysis and univariate Cox hazards regression. Multivariate regression analysis of survival times was calculated with a proportional hazards model. A p value of 0.05 was considered statistically significant. Statistical calculations were performed with the commercially available statistical software package, SPSS version 17.

3. Results

3.1. Patient characteristics

Of the 57 patients involved in this study, there were 30 (52%) females and 27 (48%) male. The mean age at first surgery was 53.98 (range 32–74). 53 patients were previously unoperated, whilst out of the remaining 4 patients, 2 patients underwent biopsy and 2 patients previous resection of the lesions in another hospital. 15 patients required reoperation over the course of follow up.

The most common clinical presentation of cerebral metastases at the initial consultation was headache (53% of patients) as a result of increased intracranial pressure. This was followed by visual problems (23%), hemiplegia/hemiparesis (19%), dysphasia (16%), ataxia (12%), dysesthesia/paresthesia (12%), seizures (11%) and memory problems (7%). All patients underwent preoperative magnetic resonance imaging (MRI) studies and/or CT scans showing that 22 patients had single metastasis, whilst 35 had multiple metastases.

The characteristics of all patients are summarized in Table 1. Patients were assigned to RPA classes based on KPS and age [10].

Table 1
Demographics of patients with single versus multiple metastases.

Patient characteristics		Age at first surgery	Range: 32–74
Mean: 53.98			
	Sex	Male: 27	Female: 30
	Previous surgery	None: 53 Biopsy/partial resection: 2 Previous resection: 2	
	Single metastasis: 30	Multiple metastases: 42 Range: 2–7 Median per patient: 4	
Presenting symptoms	Seizures: 6 Headache: 30 Hemiplegia/ hemiparesis: 11 Dysasthesia/ parasthesia: 7	Dysphasia: 9 Memory problems: 4 Visual problems: 13 Ataxia: 7	
KPS score at admission	≤70–39 (54.17%) >70–33 (45.83%) Range 40–100 Median 70	RPA class	I–29 (40.28%) II–28 (38.89%) III–15 (20.83%)
Adjuvant treatments	Preoperative radiotherapy: 17 Postoperative radiotherapy: 28	Preoperative chemotherapy: 3 Post operative chemotherapy: 2	
Surgery	Size of craniotomy Operative time Extent of resection	Mean 2.7 cm, median 3 cm Mean 194.4 min, median 177 min ≥98%: 49 90–97%: 18 ≤90%: 5	
Post operative stay	Range: 1–31 days	Median: 2 Mean: 3.31	
Follow up	Length of follow up	Range: 3–48 months Mean: 21.96 months	
Current status [a]	Alive: 29 Deceased: 43		

Many patients presented with more than one symptom.
[a] As of November 2009.