Clinical Application of Multimodality Imaging in Intracranial Tumors

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Abstract

Objective: This study was aimed to investigate the advantage of new techniques for diagnosis and treatment of intracranial small lesions.

Methods: We retrospectively analyzed the clinical data of 64 symptomatic patients suffering from intracranial small lesions and underwent magnetic resonance spectroscopy (MRS), perfusion weighted imaging (PWI) and neuro-navigation assisted surgery in the First Affiliated Hospital of Sun Yat-Sen University from January 2010 to December 2017, and evaluated the diagnosis, extent of resection and operation time.

Results: Among 8 cases of neuronal and mixed neuronal-glial tumors, 3 underwent preoperative cerebral plain MR, enhanced MR, MRS and PWI, 1 underwent cerebral plain MR, enhanced MR and MRS, whose imaging diagnoses were consistent with postoperative pathology. Another 3 cases underwent neuro-navigation assisted surgery whose tumors were totally resected. Among 19 cases of astrocytoma, 7 underwent neuro-navigation assisted surgery and their tumors were totally resected, another 12 underwent traditional craniotomy with 1 case of subtotal resection. Total resection was performed in 37 patients with cavernous hemangioma, and the operation time of 16 patients with intraoperative neuro-navigation was shorter than that of the other 21 patients with traditional craniotomy ($t = -2.164, P < 0.05$).

Conclusions: The neuronal and mixed neuronal-glial tumors could be diagnosed accurately through combining MRS with PWI, which provide theoretical reference for surgical resection. With the aid of neuro-navigation, intracranial tumors can be precisely positioned and totally resected.

Keywords: Intracranial tumors; MRS; PWI; Neuro-Navigation

Introduction

Magnetic Resonance Spectroscopy (MRS) is the non-invasive method to detect the metabolic changes and bioenergetics of normal brain tissue and intracranial tumor of patients. Perfusion Weighted Imaging (PWI) can evaluate the microcirculation of tumors. The method combining MRS with PWI could improve the diagnostic accuracy and reliability of intracranial tumors. Intracranial small lesions refer to the lesions in the brain parenchyma where the maximum diameter measured by CT or MRI is less than 3.0cm in the subcortical white matter [1, 2], which can be identified accurately by imaging examination at present.

However, the disadvantage of surgery for intracranial small lesions is that the location of the tumor is not accurate. Therefore, there is an urgent need for a new technology to make up for this deficiency. The application of neuro-navigation technology provides an accurate, safe and effective surgical method for clinical resection of intracranial small lesions [3]. This study was aimed to investigate the advantage of new techniques for diagnosis and treatment of intracranial small lesions.

Materials and Methods

Characteristics of patients

A total of 64 patients with cerebral hemispheric tumors were selected from the First Affiliated Hospital of Sun Yat-sen University from January 2010 to December 2017, including 35
males and 29 females, aged from 4 to 74 years, with an average age of 32.83 ± 14.86 years. Among them, 27 cases were located in frontal lobe, 20 cases in temporal lobe, 5 cases in insular lobe, 5 cases in parietal lobe, 3 cases in occipital lobe, 2 cases in basal ganglia and 2 cases in lateral ventricle. There were 8 cases of neuronal and mixed neuronal-glial tumors (3 cases of dysembryoplastic neuroepithelial tumor aka DNT and 5 cases of ganglioglioma aka GG), 19 cases of astrocytoma (3 cases of WHO grade I and 16 cases of WHO grade II) and 37 cases of cavernous hemangioma. MR showed that the maximum diameter of lesions was smaller than 3cm. The main clinical symptoms were epilepsy (n = 30), absence seizure (n = 5), dizziness (n = 7), headache (n = 9), syncope (n = 4), limb weakness (n = 3), vision loss (n = 2), facial numbness (n = 1), speech disorder (n = 1), disturbance of consciousness (n = 1) and mood change (n = 1). Operation time of each patient started with the use of surgical skull clamp and ends with suture of scalp.

**Inclusion criteria:** (1) Patient with corresponding clinical symptoms undergoing intracranial lesion resection for the first time (2) Maximum diameter of intracranial lesion ≤ 3 cm by preoperative MR (3) Lesions located in the cerebral hemisphere (4) Without surgical contraindications.

**Exclusion criteria:** (1) Non-first-time resection of intracranial lesions; (2) Maximum diameter of intracranial lesions > 3 cm; (3) Lesions located in the posterior cranial fossa.

**Imaging examinations**

Of the 8 patients with neuronal and mixed neuronal-glial tumors, 3 underwent preoperative cerebral plain scan, enhanced scan, MRS and PWI, 1 underwent plain scan, enhanced scan and MRS. The remaining 4 patients underwent only plain scan, enhanced scan. Nineteen cases of astrocytoma and 37 cases of cavernous hemangioma underwent preoperative MR or CT scan. All patients were re-examined by postoperative MR or CT scan.

**Intraoperative neuro-navigation**

Navigation plan: we used iPlan 3.0 (Brainlab, Munich, Germany) to import the patients’ imaging data, fuse the cross-sectional anatomy image of the same anatomic position, then used object creation to describe the tumor area and exported navigation plan at last.

Preoperative preparation: after anesthesia, we fixed patient’s head with surgical skull clamp, imported the navigation plan into the neuro-navigation workstation, performed surface registration with the positioning points of the scalp including orbit, nasal root, nasal tip and so on to match patient’s operative field accurately with the imaging data. Afterwards, the minimum scalp incision was designed by marking the tumor boundary on the scalp with the probe.

**Treatment**

Among 8 patients with mixed neuronal and neuroglial tumors, intraoperative neuro-navigation was performed in 3 cases (1 case of DNT and 2 cases of GG). In 19 patients with astrocytoma, 7 cases performed intraoperative neuro-navigation and 2 cases performed intraoperative MRI. In 37 patients with cavernous hemangioma, 16 cases performed intraoperative neuro-navigation. The remaining patients were treated with traditional surgery.

**Statistical Analysis**

Statistical software SPSS version 20.0 software (SPSS, Chicago, USA) was used for statistical analysis. The degree of tumor resection was calculated as gross total resection (no clear residue in postoperative imaging), subtotal resection (more than 90% resected), and partial resection (more than 60% resected). The tumor size and the operation time were compared by two independent samples t-test separately. \(P<0.05\) (2-tailed) was considered statistically significant.

**Results**

Eight patients with neuronal and mixed neuronal-glial tumors were firstly observed with syndrome before 30 years old, with the onset of epileptic mostly with lesions mainly located in the temporal lobe. Among them, 3 patients underwent neuro-navigation assisted operation and achieved gross total resection identified by postoperative MR (Table 1).
These type of tumours are very rare they comprise only 5% of neoplasms and are seen in 0.4-2.6 for every 100,000 cases around the world, the mucoepidermoid tumour affects parotid and minor salivary glans in adults and is mostly seen in women and young adults, most of the cases arise in the parotid gland with this case accounting for only 2-4% of the cases because it was seen in the submandibular gland, this patient is currently under treatment he was performed two surgeries for removal of ganglions located in neck and in the submandibular gland, high prevalence for this type of tumour is around the fifth decade of life and they can be asymptomatic like in this case with the patient having few to no symptoms. It has a puripotent cell origin and as we mention can be classified into three stages [3].

Among the 19 patients with astrocytoma, 7 underwent intraoperative neuro-navigation and achieved gross total resection, and 12 underwent traditional surgery while 1 of which was subtotal resection.

All the 37 patients with cavernous hemangioma underwent gross total resection. There was no significant difference in tumor size between those two groups (1.99 ±0.65cm VS 2.12 ±0.62 min, P>0.05). The operation time of 16 patients with assistance of intraoperative neuro-navigation was 214.06 ± 58.14 min, and the operation time of the other 21 cases with traditional surgery was 272.62 ±104.58 min (P<0.05). The operation time of intraoperative neuro-navigation group was shorter compared with traditional surgery group (P<0.05).
**Typical Cases**

A 27-year-old male was admitted to hospital because of recurrent sudden loss of consciousness and automatism for 1 year. He underwent cerebral plain scan, enhanced scan, MRS and PWI.

The MR inspection demonstrated a ganglioglioma in left temporal lobe. The standard ganglioglioma treatment is surgical removal of the ganglioglioma. By application of intraoperative neuro-navigation in determining tumor boundary, no obvious difference was found between the tumor and the surrounding normal brain tissue. Postoperative histopathology suggested ganglioglioma, WHO grade I (Figure 1).

**Figure 1:** A-H, The cortical and subcortical white matter of the left temporal lobe showed abnormal signal, T1WI showed equal signal, T2WI and Fair scan showed slightly high signal intensity, and no enhancement was found in contrast-enhanced scan.I-J, The Preoperative MRS imaging. K-L, The MRS imaging of normal Brain. M-N, The Preoperative PWI imaging. O-T, the postoperative MR scans showed that tumor was total resected.
Discussion

MRS could reflect the level of metabolites from the cellular level non-invasively, and can be used for quantitative analysis of metabolites [4]. PWI reflects the hemodynamic changes of brain tissue under physiological and pathological conditions [5]. MRS and PWI techniques are beneficial to the accurate diagnosis of neuronal and mixed neuronal-glial tumors and provide the theoretical reference for surgical resection. With the assistance of neuro-navigation, intracranial small lesions could be localized accurately, which reduce risk of surrounding tissue damage and bring more possibility of total resection.

Intracranial small lesion refers to the brain parenchyma lesions whose maximum diameter is less than 3.0 cm measured by CT scan or MR in the subcortical white matter. Total resection is an independent prognostic factor in the surgical treatment of gliomas, suggesting the crucial role of the rate of total resection in improving the therapeutic effect of glioma [6]. It is difficult to accurately locate the intracranial small lesions in the cerebral hemisphere before operation.

Neuro-navigation has many advantages in the resection of intracranial small lesions, such as accurate marking of tumor boundary, real-time location during operation enables the search of the shortest path to deep lesions, and dynamic observation of tumor resection is beneficial to improve the extent of tumor resection [7]. Compared with the traditional surgery, neuro-navigation assisted surgery requires preoperative navigation registration and localization, and it takes a certain amount of time to determine the tumor boundary and the extent of resection. However, in this study, the tumors of all patients with neuro-navigation assisted operations achieve gross total resection of the lesions, and it takes less time and reduces the risk of surgical anesthesia. In addition, MRS and PWI techniques are beneficial to the accurate diagnosis of neuronal and mixed neuronal-glial tumors, and provide a basis for surgical resection.

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References