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Safety and Efficacy of Frameless Stereotactic Brain Biopsy Techniques

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Key words: stereotaxis; frameless; biopsy; histology

Objective To explore the safety and efficacy of frameless stereotactic brain biopsy.

Methods Diagnostic accuracy was calculated by comparing biopsy diagnosis with definitive pathology in 62 patients who underwent frameless stereotactic brain biopsy between January 2008 and December 2010 in Xiamen University Southeast Hospital. Preoperative characteristics and histological diagnosis were reviewed and then information was analysed to identify factors associated with the biopsy not yielding a diagnosis and complications.

Results Diagnostic yield was 93.5%. No differences were found between pathological diagnosis and frozen pathological diagnosis. The most common lesions were astrocytic lesions, included 16 cases of low-grade glioma and 12 cases of malignant glioma. Remote hemorrhage, metastasis, and lymphoma were following in incidence. Multiple brain lesions were found in 17 cases (27.4%). Eleven cases were frontal lesions (17.7%), 8 were frontotemporal (12.9%), 6 were frontoparietal (9.7%), and 5 each were temporal, parietal, and parietotemporal lesions (8.1%). Postoperative complications occurred in 21.0% of the patients after biopsies, including 10 haemorrhages (16.1%) and 3 temporary neurological deficits (1 epilepsy, 1 headache, and 1 partial hemiparesis). No patient required operation for hematoma evacuation.

Conclusion Frameless stereotactic biopsy is an effective and safe technique for histologic diagnosis of brain lesions, particularly for multifocal and frontal lesions.

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FRAME-BASED techniques have been the standard method to achieve a reliable and accurate sampling of intracranial lesions and have been shown to be superior to freehand biopsy procedures in terms of morbidity, mortality, and diagnostic yield.[1,2] Recently, frameless stereotaxis has been rapidly embraced by most neurosurgeons to the extent that it is quickly supplanting frame-based techniques in general neurosurgical practice. Some reports have suggested that frameless techniques are as good as or better than the traditional frame-based approaches.[3,4] The relative diagnostic yield and candidacy of frameless as well as its complications

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are areas for ongoing debate. Thus the relative role of frameless in neurosurgical practice warrants further study.

PATIENTS AND METHODS

Patients

A consecutive series of patients who had undergone frameless image-guided stereotactic intracranial biopsy at the Department of Neurosurgery of Xiamen University Southeast Hospital from January, 2008 to December, 2010 were studied. The information of all the patients were entered into, and followed with a retrospective clinical outcomes database. General features (age, gender) were retrospectively collected from patient records. Patients with multifocal solid lesions underwent stereotactic biopsy only if they did not have a history of primary-histology-proven malignancy, and only if systemically examined with chest, abdomenal, and pelvis computed tomography (CT).

Preoperative neuroimaging characteristics

The sites of lesions were identified with preoperative CT or magnetic resonance imaging. Information about events associated with the operation, such as biopsy method used and postoperative complications were extracted from the operation report and patient records. The diagnoses were obtained from the pathological reports.

Frameless image-guided stereotactic biopsy

Contrast-enhanced magnetic resonance imaging (pre- and post-contrast T1-weighted, 2-mm slices) scans were conducted a maximum of 24 hours before the operation. All the operation were performed under general anaesthesia and the patients' heads were fixed in a three-point Mayfield clamp (Integra LifeSciences Corp., Plainboro, NJ, USA). Intraoperative image guidance was performed using neuronavigation (BrainLab AG, Heimstetten, Germany). The surgical plan, and thus the entry point, biopsy target, and needle trajectory, were determined preoperatively using neuronavigation. After registration was completed and the accuracy of the neuronavigation system confirmed using anatomic landmarks, burr hole craniotomy was performed. The needle was then attached to the Mayfield clamp and held with a burr hole fixation needle trajectory guide.

Statistical analysis

The enumeration data were expressed as number of cases and percentage. In order to analyse factors relating to the sites of lesion, and postoperative complications related to frameless stereotactic biopsy, the variables were explored univariately.

RESULTS

Altogether 62 patients were selected in the present study, including 33 males and 29 females. The median age was 43.2±16.7 years (range, 11-72 years). Table 1 summarizes the information of the patients and the events related to frameless stereotactic biopsy.

Most cases were with multiple lesions (17/62, 27.4%), and the lesions with the highest frequencies were frontal (11/62, 17.7%), frontotemporal (8/62, 12.9%), frontoparietal (6/62, 9.7%), and temporal, parietal, parietotemporal lesions (all 5/62, 8.1%) (Table 2). Of the 62 consecutive diagnostic biopsies performed, pathological histological diagnosis was obtained in 93.5%. The 62 cases included 51 cases of neoplastic lesions and 11 cases of non-neoplastic lesions (Table 3). The most common diagnosis was astrocytic tumors, including 16 cases of low-grade glioma and 12 cases of malignant glioma, followed by remote hemorrhage (7 cases), metastasis (6 cases), and lymphoma (6 cases). In 10 cases, hemorrhage was noted in postoperative CT (16.1%). The other postoperative complications included epilepsy, symptomatic headache, and partial hemiparesis (all 1/62, 1.6%).

Table 1. Preoperative characteristics and symptoms and signs related to biopsy (n=62)

Features	Number of cases	Percentage (%)
Male	33	53.2
Female	29	46.8
Headache	27	43.5
Epilepsy	22	35.5
Motor weakness	11	17.7
Lalopathy	7	11.3
Cerebellar signs	3	4.8
Tinnitus	1	1.6
Mental disorder	1	1.6

Table 2. Preoperative anatomical localization of the lesions chosen for biopsy

Location	Number of cases	Percentage (%)
Multiple lesions	17	27.4
Frontal	11	17.7
Temporal	5	8.1
Parietal	5	8.1
Insular lobe	1	1.6
Frontotemporal	8	12.9
Frontoparietal	6	9.7
Parietooccipital	1	1.6
Parietotemporal	5	8.1
Temporooccipital	3	4.8

Table 3. Definitive histological diagnosis and biopsy-related diagnosis (n = 62)

Lesions	Pathological diagnosis (n)	Frozen pathological diagnosis (n)
Neoplastic		
Low-grade glioma	16	13
Malignant glioma	12	11
Lymphoma (NHL B cell)	6	6
Metastasis	6	6
Gliosis	5	7
Mixed glioma	3	3
Hemangioma	2	3
Yolk sac tumor	1	1
Non-neoplastic		
Hemorrhage	7	8
Cysticercosis	2	2
Tuberculosis	2	2

DISCUSSION

The treatment of intracranial lesions largely depends on the histological diagnosis. Frameless stereotactic technique (also called frameless neuronavigation) has been accepted as a feasible tool for intracranial biopsy with good accuracy and little mortality, compared with frame-based techniques which have been considered as the gold standard for sampling intracranial lesions.[1,2] Given the increasing popularity of frameless neuronavigation systems in stereotactic biopsy, it may be helpful to establish criteria for patients selection through which we could determine the suitability of frameless stereotactic techniques. In the present study, lesions had to satisfy anatomic location conditions besides being at least 15-mm in size. Lesions at the following locations were excluded: (1) infratentorial, basalganglia, thalamus, or pineal; (2) adjacent to the Circle of Willis or root of the sylvian fissure. Owen *et al*[3] reported that 80% lesions are candidates for frameless stereotactic techniques, and the remaining 20% small or deeply seated lesions still depend on frame-based stereotaxy. The anatomical location of the lesion might have influence on both the diagnostic yield and the risk of complications. Due to postoperative hemorrhage or edema, a deeply seated lesion at the midline or sylvian fissure is associated with a higher incidence of complication or not obtaining a diagnosis on histopathologic examinaion. In this study, a lesion located in the insular lobe with a maximum diameter of 20 mm was not revealed in the histological diagnosis. The reason was brain shift resulted from cerebrospinal fluid diversion. Concerning the size of lesion, Woodworth *et al*[5] reported that large lesions, with a maximum diameter greater than 2 cm, were 5-fold more likely to yield a diagnostic biopsy.

The data of the present study support the notion that frameless stereotactic biopsy is an effective method to establish tissue diagnosis for intracranial lesions. The diagnostic yield of frameless stereotaxy in this study is 93.5%, within the range of diagnostic yield (90%-96%) previously reported.[5-9] The diagnostic yield reported by Owen *et al*[3] was 90.9%. Dammers *et al*[4] reported an overall diagnostic yield of 89.4% (89.7 and 88.9% for frame-based and frameless biopsy procedures, respectively).

The specific method and number of biopsy bits likely play a key role in determining diagnostic accuracy and yield. As other researchers did,[5,9,10] we tended to select a side-cutting needle, which has the advantage of preserving a core of intact cross-sectional tissue architecture, facilitating histological interpretation. Multiple sections were taken with the needle at serial depths along the single trajectory. This method allows the obtainment of different tissues at different depths, providing samples of normal brain, lesion edge, and central contents. The utility of this approach was reflected in the diagnostic accuracy except for 4 cases in this study. The 4 cases were confirmed finally (2 cases of gliosis and 2 cases of remote hemorrhage). Jain *et al*[11] found that the diagnostic accuracy increased from 76.5% for single biopsies to 84% and 88.2% for 2 and 3 samples, respectively, and 100% for biopsies with 5 to 6 samples. A contrary view was offered by Dammers *et al*,[4] who reported no relationship between the number of tissue samples and the diagnostic yield.

An important use of frameless stereotactic biopsy is confirming tissue diagnosis for patients with neoplastic brain lesions. In the present study, astrocytic lesions were the most common, including 16 cases of low-grade glioma and 12 cases of malignant glioma. Twenty-four of the 62 patients who had a definite histological or microbiological diagnosis on needle biopsy subsequently underwent open craniotomy following the original biopsy. Review of these pathology results were in accordance with those obtained with the frameless stereotactic needle biopsy.

It is important to understand the practical safety of frameless stereotactic biopsy. Damage to blood vessels in the biopsy trajectory is often unavoidable, due to the surgeon's inability to directly see the result of manipulation. A distinct advantage of software for pre-surgical planning with the frameless biopsy technique is that the surgeon is able to scroll through the trajectory path and plan to avoid crossing pial and arachnoid surfaces in order to reduce the risk of hemorrhage. In the patients in this study, Z-Touch system was applied for pre-surgical planning, and little blood was noted in the needle or the specimen during the procedure. The subsequent bleeding was found at the biopsy site on post-biopsy CT. Only 3 patients developed new clinical temporary neurological symptoms (1 epilepsy, 1 headache, and 1 partial hemiparesis) and no one developed permanent new neurological symptoms. No patient required operation for cerebrospinal fluid diversion or for hematoma evacuation as a result of frameless stereotactic biopsy.

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