Available online at www.sciencedirect.com
ScienceDirect
Journal of the Chinese Medical Association 74 (2011) 110−114
www.jcma-online.com

Original Article

Stereotactic biopsy for brainstem lesion: Comparison of approaches and reports of 10 cases

Se-Yi Chen [a], Chien-Hua Chen [a], Ming-Hsi Sun [a], Hsu-Tung Lee [a,*], Chiung-Chyi Shen [a,b]

[a] *Department of Neurosurgery, Taichung Veterans General Hospital, Taichung, Taiwan, ROC*
[b] *Faculty of Medicine, National Yang-Ming University School of Medicine, Taipei, Taiwan, ROC*

Received August 19, 2010; accepted September 17, 2010

Abstract

Background: Stereotactic biopsy for brainstem lesion offers high diagnostic yield with low morbidity. We compared two modalities of biopsy procedure, frame-based and frameless stereotaxy, either transfrontal or transcerebellar route. The benefits and operation considerations are discussed.
Methods: Ten patients with intrinsic brainstem lesion diagnosed with stereotactic biopsy from August 2006 to March 2010 were retrospectively reviewed. All procedures were performed under general anesthesia. Six of 10 patients were approached with transfrontal route, whereas the other four patients with transcerebellar route. Frame-based stereotaxy or frameless navigation system was applied.
Results: All lesions of the 10 patients were successfully diagnosed with stereotactic biopsy procedure. There was no major morbidity after the procedure.
Conclusion: A number of approaches are available for stereotactic brainstem biopsy. Surgical approach should be tailored, according to the location neurological function, with special concern for the patients' safety. In selected condition, frameless stereotaxy biopsy also provides competed diagnostic yield.

Keywords: Brainstem; Frameless; Neuronavigation; Stereotactic biopsy

1. Introduction

Brainstem tumor comprises 10−15% in pediatric group, but only 2% in adult group.[1] Owing to the diversity of diagnoses and risk of surgical approach, lesions in the brainstem have been a challenge. The treatment protocol and predicted outcome also depend on the histological diagnosis. Stereotactic biopsy is referred as an effective procedure with high diagnostic yield and acceptable complication rate. The proper biopsy policy, transcerebral or transcerebellar, frame-based or frameless stereotaxy, is still matters of debate. We report our experiences in different approaches, comparison of different methods, and literature reviews.

2. Methods

We retrospectively reviewed the medical records of all patients with symptomatic brainstem and/or cerebellar peduncle lesions who had undergone stereotactic biopsy at our institute from August 2006 to March 2010. Ten patients, whose age ranged from 3 to 86 years old, were enrolled. Demographic and clinical data are summarized in Table 1. The image investigations included brain computed tomography (CT), magnetic resonance image (MRI) with and without contrast, and magnetic resonance spectroscopy (MRS). Stereotactic procedures were performed with either Leksell frame-based system or BrainLAB frameless system. Before 2007, all

* Corresponding author. Dr. Hsu-Tung Lee, Department of Neurosurgery, Taichung Veterans General Hospital, 160, Section. 3, Chung-Kang Road, Taichung 407, Taiwan, ROC.
E-mail addresses: leesd2001@hotmail.com, amore0102@yahoo.com.tw, s861085@gmail.com (H.-T. Lee).

1726-4901/$ - see front matter
doi:10.1016/j.jcma.2011.01.024

Table 1
Demographics of 10 patients with brainstem lesion diagnosed by stereotactic biopsy

Case no.	Age (yr)/sex	Location	MRI finding[a]	MRS[b]	Surgical position	Trajectory	Stereotaxy system	Histological diagnosis	Complication
1	8/F	Rt midbrain, pons and cerebellar peduncle	Diffuse T2WI and FLAIR ↑ contrast enhance →	Reverse NAA/Cho	Supine	Transfrontal	Leksell	Diffuse astrocytoma (grade II)	Transient diplopia and facial paresthesia
2	9/M	Rt pons	Diffuse T2WI and FLAIR↑ contrast enhance ↑	Reverse NAA/Cho	Supine	Transfrontal	Leksell	A.A (grade III)	Facial paresthesia
3	31/F	Midbrain and pons cystic tumor	Exophytic lobulated lesion with cysts form	Not available	Supine	Transfrontal	BrainLAB	Neurilemomma	None
4	44/F	Lt midbrain	lesion with contrast enhance ↑	Not available	Supine	Transfrontal	Leksell	Metastatic adenocarcinoma	None
5	43/F	Rt midbrain	T2WI and FLAIR ↑ contrast enhance ↑	Reverse NAA/Cho	Supine	Transfrontal	Leksell	A.A (grade III)	None
6	12/F	Rt midbrain, pons and cerebellar peduncle	T2WI and FLAIR ↑ contrast enhance↓	Not available	Lateral (Lt)	Transcerebellar	BrainLAB	A.A (grade III)	None
7	86/M	Lt midbrain, pons, and cerebellar peduncle	T2WI and FLAIR ↑ contrast enhance ↑	Reverse NAA/Cho	Lateral (Rt)	Transcerebellar	BrainLAB	Glioblastoma (grade IV)	None
8	30/M	Rt midbrain and pons	T2WI and FLAIR ↑ contrast enhance→	Reverse NAA/Cho	supine	Transfrontal	Leksell	High grade glioma (grade III)	None
9	30/F	Lt pons to medulla oblongata	T2WI and FLAIR ↑ contrast enhance↓	Reverse NAA/Cho	Lateral (Rt)	Transcerebellar	BrainLAB	Diffuse astrocytoma (grade II)	None
10	3/F	Diffuse pons	T2WI and FLAIR ↑ contrast enhance↓, encase the basilar a.	Reverse NAA/Cho	Lateral (Lt)	Transcerebellar	BrainLAB	Fibrillary astrocytoma (WHO grade II)	None

[a] ↑ means high signal and good contrast enhancement; → means isosignal and no obvious contrast enhancement; [b] reverse NAA/Cho indicates malignant brain tumor.
BrainLAB = BrainLAB -Kolibri frameless navigation system; NAA = N-acetyl aspartate; Cho = Choline; A.A = Anaplastic astrocytoma; MRI = magnetic resonance imaging; MRS = magnetic resonance spectroscopy.

stereotactic biopsy procedures were performed with Leksell stereotactic frame-based system. All operations were performed under general anesthesia. The planning procedures and operation details are listed in Table 1. Frozen section was performed for all cases to prevent negative sampling. Final diagnosis was made according to the permanent section with immunohistological exam.

3. Results

All samplings led to a histological diagnosis. Five patients were planned with Leksell frame-based system, and the others with Frameless BrainLAB system. Six (6/10) patients were approached transfrontally, whereas the other four patients (4/10) via transcerebellar route. The histological diagnosis showed diversity. Low-grade glioma (grade II) was found in three, high-grade glioma in five, metastases in one, and neurilemomma in one (Table 1). For the patient with neurilemomma (Case 3), because of the cystic component with mass effect to brainstem, a cystoperitoneal shunt was also implanted in the same operation. One patient developed transient diplopia and facial paresthesia, and the other facial paresthesia. Immediate post-operation brain CT was performed to exclude intracranial hemorrhage. The patients were treated conservatively because of negative brain CT finding. All complications recovered within 1 day after steroid therapy. There were nonpermanent complications (Table 1).

3.1. Case illustrations

3.1.1. Case 2

A 9-year-old boy presented with diplopia and unstable gait for 2 weeks. He also had right-limb muscle power mildly worse than that of his left limb. Brain MRI showed infiltrative lesion at pons, with low signal on T1WI and high signal on T2WI. With Leksell frame-based system, we performed left transfrontal trajectory, with the target set at the center of lesion. Left side was chosen because of the relative right hemiparesis (Fig. 1).

3.1.2. Case 9

This 30-year-old woman presented with persistent headache and progressive left upper limb weakness for 1 month. Brain image showed a diffuse brainstem lesion. We choosed suboccipital approach with frameless stereotactic biopsy with the BrainLAB navigation system. To fulfill the image requirement for reconstruction, we performed 3-mm thickness slices of CT. Then we used fusion technique for navigation planning. The patient was postured in lateral position, and we labeled artificial markers around the lateral facial feature to facilitate registration. Under navigation, the venous sinus was depicted and kept free from injury (Fig. 2).

4. Discussion

Stereotactic brainstem biopsy can be approached either with transfrontal or transcerebellar route. Frame-based stereotactic biopsy has been regarded as standard procedure. With the advance of software and image quality, the application of frameless navigation system is increasing. The considerations of biopsy modality are: avoiding complication, avoiding brain shifting, patient safety and comfort, and adequate tissue access.

4.1. Frame-based or frameless stereotaxy

Stereotactic biopsy for brainstem lesions has been performed since 1978.[2] The procedure of frame-based stereotactic biopsy for brainstem lesion is well established, and referred to as the gold standard procedure. Frameless navigation system provides intraoperation real-time reference and allows us to perform multiple different trajectories. It has been compared with frame-based technique in the aspects of diagnostic yield and surgical morbidity. Both methods offer around 90%

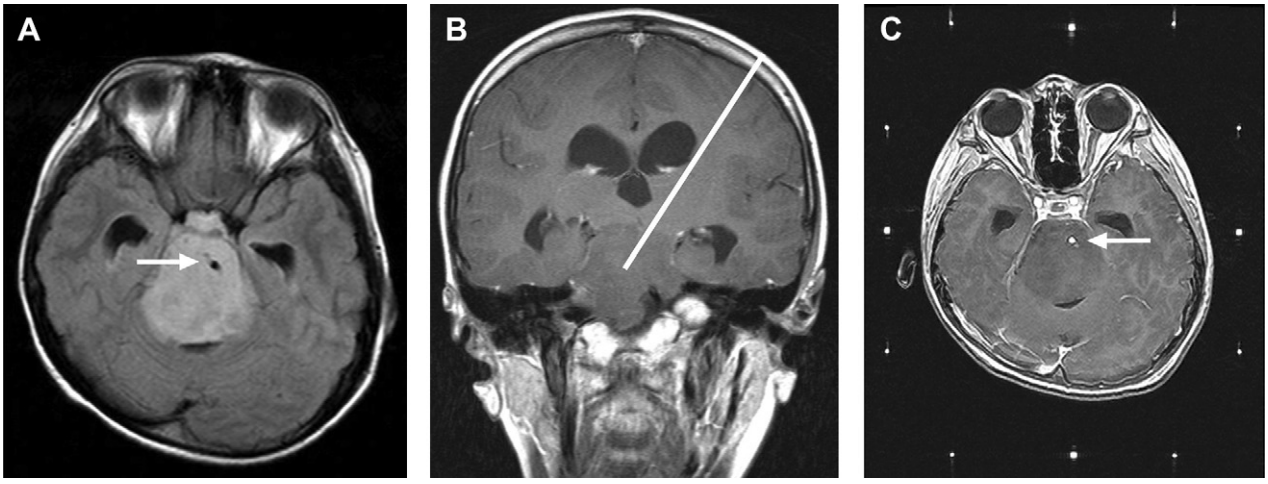

Fig. 1. (A) MRI T2 FLAIRAxial view. (B) MRI T1WI+Gd enhancement did not show obvious enhancement of the lesion. The white-line is the simultation of trajectory. Note the trajectory passed by the ventricle structure. (C) Planning image with 3D-TOF, which offers clear image of vessels. The basilar artery (white arrows) was encased in the lesion. Planned trajectory should be kept away from that. MRI = magnetic resonance imaging.

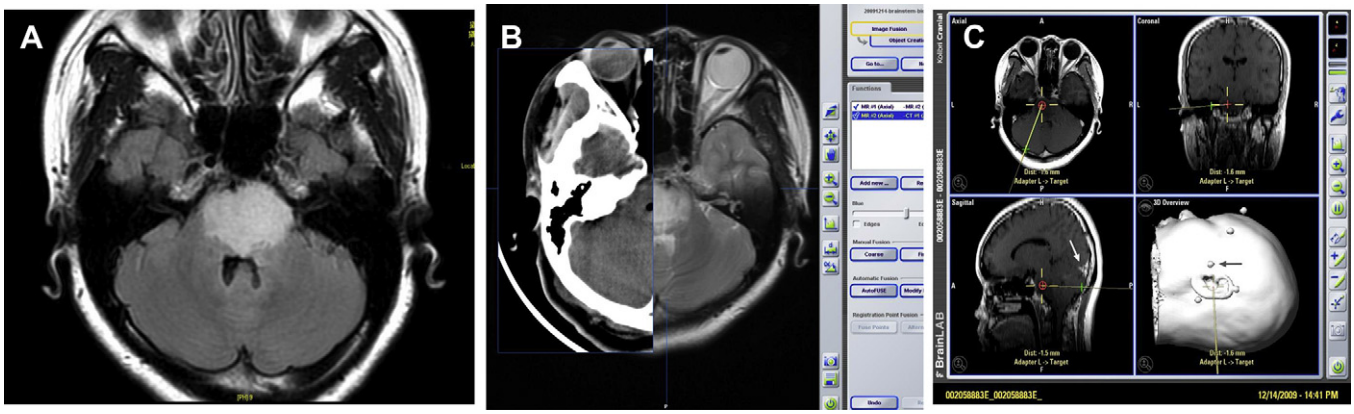

Fig. 2. (A) T2 FLAIR image showed diffuse pontine lesion. (B) Fusion technique to facilitate image reconstruction. (C) Intra-operation navigation. Note the marks (grey arrow) around left ear were used for image registration. The venous sinus (white arrow) can be illustrated and kept intact.

diagnostic rate.[3,4] Barnett et al reported the diagnosis rate to be 97.6% using frameless stereotaxy for 208 supratentorial lesions, but only 70% for 10 infratentorial lesions.[5] However, the article didn't provide information about trajectory routes. Frameless stereotaxy seemed to have limitation in application for infratentorial lesions. The error probably comes from long trajectory and far distance from the lesions to registration markers.

Transcerebellar approach offers the shortest trajectory for pons and cerebellar peduncle. In our series, we performed transcerebellar approach in 4 patients (Case no. 6, 7, 9, and 10) with application frameless navigation guide. To surmount the problem of registration error, we combined using fiducial markers and lateral facial features, like tragus, external auditory meatus, and mastoid process, as landmarks for registration (Fig. 2). Mayfield head clamp is mandatory to assure immobilization of the head, which is essential in stereotactic procedure. In this way, the registration markers are closer to the lesion and offer better reference to navigation. Reports of application of frameless navigation guide procedure for infratentorium lesion remain limited. We think more data is required to achieve conclusion.

4.2. Transcerebral (transfrontal) and transcerebellar approach

Biopsy trajectories to brainstem lesion have been one of the following: (1) transfrontal approach for mesencephalon or superior pons; or (2) suboccipital transcerebellar approach for lower pons or cerebellar peduncle.[6,7] Both approaches have pros and cons. When performing suboccipital transcerebellar approach, dissection of the nuchal musculature often leads to more wound pain. Lateral or prone position requires more safety concern. Transfrontal approach with supine position takes advantage of safety and convenience.

Because of the small volume, bleeding in the posterior fossa is more threatening. The ventricle structures, which are lined with choroid plexus, ependymal cells and pia layer, should be kept away from the trajectory to reduce intracranial hemorrhage and intraventricular hemorrhage.[6,7] Suboccipital transcerebellar approach via middle cerebellar peduncle provides less possibility of penetrating ventricle structures, and therefore reduces the risk of hemorrhage. The navigation system also helps in preventing injury to large vessels and venous sinus structures (Fig. 2).

Deep-seated location is an independent factor of accuracy.[5,8] Giese et al showed a deviation distance of 2.2 ± 1.18 mm on MR image, with the mean transfrontal trajectory length 85.9 ± 4.7 mm, although the suboccipital trajectory, with mean 59.5 ± 4.1 mm length, showed only 1.81 ± 0.7 mm target deviation. Although this was a laboratory investigation in cadaveric model and there was no clinical reference about the acceptable deviation distance, the relationship between the trajectory length and target deviation is established.[10] Transcerebellar via middle cerebellar peduncle offers the shortest route toward the pontine lesion.

Small lesion size is also a potential risk of nondiagnostic sampling, in both frame-based and frameless groups. The article showed lesion smaller than 2 cm accounts for nondiagnostic sampling.[3] The limitation of lesion size remains uncertain and requires more data to achieve conclusion.

4.3. Transfrontal ipsilateral or contralateral approach

Ventricle penetration with cerebrospinal fluid (CSF) loss may lead to target shifting. We had failure experiences in stereotaxy aspiration because of CSF loss, although there was one case report of transfrontal transventricular approach without the problem of target shifting or hemorrhage.[9] We still recommend avoiding passing through ventricles when possible. Contralateral transfrontal approach provides an alternative route without ventricular penetration.[7] In selected case, contralateral transfrontal approach offers a better access to laterally locating lesions, which might be restricted by the tentorium if approached ipsilaterally. There were only two case reports about contralateral approach.[9,11] Concurrent neurological deficits should be taken into consideration for decision-making. In Case 2, we performed left-side approach because of the relatively

mild right-limb weakness. We recommend introducing the biopsy probe slowly to avoid tract disruption.

4.4. Others

Most of the procedures described in literature reviews were performed under local anesthesia and intermittent intravenous sedation agent, except one with general anesthesia.[10] We think general anesthesia offers a more tolerable atmosphere for the patients. When performing procedures around the brainstem, respiratory compromise is unpredictable and sometimes catastrophic. Emergent intubation and resuscitation are occasionally required. Lateral position makes prompt resuscitation difficult. According to our results, from a small data base, there was no increase in peri-operation neurological complication. We think general anesthesia provides safer promise and better patient compliance without increasing neurological complication.

The necessity of performing brainstem biopsy in children remains a debate. Some authors suggested that infiltrative brainstem lesions in children can be reliably diagnosed according to MRI finding without tissue proof,[11−13] while many authors approved biopsy procedure and emphasized avoiding unnecessary radiation therapy, which may lead to secondary malignancy.[7,15] From our literature review, the mismatch of pre-operative radiological diagnosis with histological diagnosis happened in about 10−20% of cases.[11, 14,15] In our series, the radiologist successfully diagnosed brainstem glioma (8 patients) according to the MRI and/or MRS, but failed in predicting the tumor grade. In Taiwan, the payment for alkylating agent (Temozolomide) from the National Health Insurance is according to definite pathology report. Tissue diagnosis nowadays plays an increasing role in brain tumor treatment, in both pediatric and adult groups, because many new treatment protocols and targeted therapy are being developed based on genetic analysis and immunochemistry study. Our attitude toward brainstem lesions is changing.

In conclusion, a number of approaches are available for brainstem stereotactic biopsy, including the ipsilateral or contralateral transfrontal, and suboccipital transcerebellar routes. Surgical approach should be tailored to each case, with consideration of safety, accuracy, and efficacy, according to the location, neurological function, and patient tolerance. The refinement of registration procedure makes frameless navigation more applicable.

Acknowledgment

All authors have read and approved submission of the manuscript. The authors would like to thank to technologist, Shu-men Tai, who contributed perfectly in image processing.

References

1. Laigle-Donadey F, Doz F, Delattre JY. Brainstem gliomas in children and adults. *Curr Opin Oncol* 2008;**20**:662−7.
2. Gleason CA, Wise BL, Feinstein B. Stereotactic localization (with computerized tomographic scanning), biopsy, and radiofrequency treatment of deep brain lesions. *Neurosurgery* 1978;**2**:217−22.
3. Woodworth GF, McGirt MJ, Samdani A, Garonzik I, Olivi A, Weingart JD. Frameless image-guided stereotactic brain biopsy procedure: diagnostic yield, surgical morbidity, and comparison with the frame-based technique. *J Neurosurg* 2006;**104**:233−7.
4. Dammers R, Haitsma IK, Schouten JW, Kros JM, Avezaat CJ, Vincent AJ. Safety and efficacy of frameless and frame-based intracranial biopsy techniques. *Acta Neurochir (Wien)* 2008;**150**:23−9.
5. Barnett GH, Miller DW, Weisenberger J. Frameless stereotaxy with scalp-applied fiducial markers for brain biopsy procedures: experience in 218 cases. *J Neurosurg* 1999;**91**:569−76.
6. Hood TW, Gebarski SS, McKeever PE, Venes JL. Stereotaxic biopsy of intrinsic lesions of the brain stem. *J Neurosurg* 1986;**65**:172−6.
7. Amundson EW, McGirt MJ, Olivi A. A contralateral, transfrontal, extraventricular approach to stereotactic brainstem biopsy procedures. Technical note. *J Neurosurg* 2005;**102**:565−70.
8. Giese H, Hoffmann KT, Winkelmann A, Stockhammer F, Jallo GI, Thomale UW. Precision of navigated stereotactic probe implantation into the brainstem. *J Neurosurg Pediatr* 2010;**5**:350−9.
9. Pereira EA, Jegan T, Green AL, Aziz TZ. Awake stereotactic brainstem biopsy *via* a contralateral, transfrontal, transventricular approach. *Br J Neurosurg* 2008;**22**:599−601.
10. Abernathey CD, Camacho A, Kelly PJ. Stereotaxic suboccipital transcerebellar biopsy of pontine mass lesions. *J Neurosurg* 1989;**70**:195−200.
11. Pincus DW, Richter EO, Yachnis AT, Bennett J, Bhatti MT, Smith A. Brainstem stereotactic biopsy sampling in children. *J Neurosurg* Feb 2006;**104**(Suppl 2):108−14.
12. Albright AL, Packer RJ, Zimmerman R, Rorke LB, Boyett J, Hammond GD. Magnetic resonance scans should replace biopsies for the diagnosis of diffuse brain stem gliomas: a report from the Children's Cancer Group. *Neurosurgery* 1993;**33**:1026−9. discussion 1029-30.
13. Steck J, Friedman WA. Stereotactic biopsy of brainstem mass lesions. *Surg Neurol* 1995;**43**:563−7. discussion 567−8.
14. Coffey RJ, Lunsford LD. Stereotactic surgery for mass lesions of the midbrain and pons. *Neurosurgery* 1985;**17**:12−8.
15. Giunta F, Marini G, Grasso G, Zorzi F. Brain stem expansive lesions: stereotactic biopsy for a better therapeutic approach. *Acta Neurochir Suppl (Wien).* 1988;**42**:182−6.