

The Accuracy and Diagnostic Yield of Computerized Tomography Guided Stereotactic Biopsy in Brain Lesions

Bilgisayarlı Tomografi Eşliğinde Yapılan Stereotaktik Beyin Biyopsilerinde Histopatolojik Tanı Verim ve Doğruluğu

ABSTRACT

OBJECTIVES: Radiological imaging techniques provide early detection of neurological diseases but they do not always provide an adequate and reliable diagnosis. With the help of stereotactic biopsy techniques, it is possible to access brain lesions safely and with high precision. We described the surgical method used in our clinic and discussed our results with the help of the current literature.

METHODS: Ninety-four patients underwent computerized tomography-guided stereotactic brain biopsy in our clinic. Anatomical locations, diagnostic yield and accuracy of the procedure, morbidity and mortality rates were analyzed.

RESULTS: A total of 100 stereotactic surgery procedures were performed on 94 patients. The localizations of the lesions were 13.83% frontal, 21.27% temporal, 27.66% parietal, 4.25% occipital, 4.25% multiple, 27.66% deep seated and 1.06% suprasellar. The histopathological diagnoses were 61.71% neuro-epithelial tumors, 8.51% metastases and 10.64% infectious lesions. Diagnostic yield was 86.16% and the accuracy was 90% in our series.

CONCLUSION: Computerized tomography-guided stereotactic brain biopsy is a reliable and safe method. Main diagnostic problems in SBB are tissue heterogeneity, insufficient material and sampling error. These problems can be minimized by careful correlation of clinical, radiological and histopathological findings by an experienced team and by using modern technologies.

KEY WORDS: Computerized tomography, Diagnostic accuracy, Diagnostic yield, Stereotactic biopsy, Brain

Öz

AMAC: Radyolojik görüntüleme teknikleri nörolojik hastalıkları erken safhada saptayabilmekte ancak uygun tedavinin başlanması için kesin ve güvenilir histopatolojik tanı sağlamakta yetersiz kalmaktadır. Stereotaktik yöntemlerle yapılan biyopsiler bu lezyonlardan güvenli ve hassas olarak örnekler alınmasını sağlamaktadır. Bu çalışmada kliniğimizde uygulanan stereotaktik cerrahi yöntemini ve sonuçlarını literatür bilgileri eşliğinde tartıştık.

YÖNTEMLER: Kliniğimizde toplam doksandört hastaya bilgisayarlı tomografi eşliğinde stereotaktik beyin biyopsisi uygulandı. Bu hastalara ait mortalite ve morbidite oranları ile lezyonların lokalizasyonu ve yöntemimizin tanı koymadaki başarısı analiz edildi.

SONUÇLAR: Toplam 94 hastaya 100 stereotaktik biyopsi işlemi uygulandı. Lezyonların yerleşimi; %13.83 frontal, %21.27 temporal, %27.66 pariyetal, %4.25 oksipital, %4.25 multipl, %27.66 derin yerleşimli ve %1.06 suprasellar şeklindeydi. Histopatolojik tanıları; %61.71 nöroepitelyal tümörler, %8.51 metastazlar ve %10.64 enfeksiyöz sebepler olarak bulundu. Yöntemimizin tanı koyma oranı %86.16 ve tanı kesinliği %90 olarak tespit edildi. Cerrahi yonteme bağlı hiçbir mortalite ve morbiditeye rastlanmadı.

SONUÇ: İntrakraniyal lezyonların teşhisinde bilgisayarlı tomografi eşliğinde yapılan stereotaktik biyopsi yöntemi güvenli ve güvenilir sonuçlar vermektedir. Tanı koymadaki problemler hedef lezyonun heterojen yapıda olması, yetersiz materyal alınması ve yanlış hedef belirlenmesi olarak sıralanabilir. Bu problemler klinik, radyolojik ve histopatolojik verilerin tecrübeli bir ekip tarafından değerlendirilmesi ve modern teknolojiler kullanılması ile çözülebilir.

ANAHTAR SÖZCÜKLER: Bilgisayarlı tomografi, Tanı verimi, Tanısal doğruluk, Stereotaktik biyopsi, Beyin

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INTRODUCTION

The advances in radiological imaging techniques provide early detection of neurological diseases. However, none of these techniques is able to provide an adequate and reliable diagnosis to constitute a definitive treatment modality. After Horsley and Clarke introduced the application of stereotactic surgery in the rat brain, the technique of the stereotaxy has constantly evolved and become popular in the neurosurgery practice [17]. Maroon et al. first reported the combination of computerized tomography (CT) and stereotactic methodology in 1977 [26]. Since then, with the help of the image-guided stereotactic applications, it is possible to access a target with high precision for the diagnosis and/or treatment of many neurological diseases with low morbidity and mortality rates.

The aim of this report is to analyze our series of CT-guided stereotactic brain biopsies (CT-SBB) and to elucidate the accuracy and diagnostic yield of this technique based on histopathological results. We described the surgical method used in our clinic, the variety of the diseases for which stereotactic surgery was applied and evaluated our results with the help of current literature.

MATERIALS and METHODS

A total of 94 patients underwent CT-guided stereotactic brain biopsy procedure between the year 1996 and 2007 in our clinic. Only the patients with visible lesions on CT were considered for the stereotactic biopsy procedure. The gender distribution was 40.43% (n=38) female and 59.57% (n=56) male and the mean age was 43.86 ± 18.75 years (range 4-77). We used an arc-based frame system (Fischer ZD, Germany) for all stereotactic biopsy procedures.

Hematoxylin and eosin (HE) stains were applied on paraffin sections for histopathological examination of the cases. Appropriate immunohistochemical studies were also added when necessary. We did not use intra-operative frozen sections or smear cytology for pathological examination. Clinical and radiological information of the patients were given to a dedicated neuropathologist for overall histopathological examination and diagnosis.

The diagnostic yield was defined as the percentage of the cases in which a definitive histopathological diagnosis could be reached in the

first stereotactic biopsy session and the diagnostic accuracy is defined as determination of the correct tumor type and grade in this study.

Stereotactic biopsy procedure

All patients were tested for coagulation parameters before the surgery. Patients using anti-platelet treatment were instructed to stop medication at least five days before the surgery. After cleansing of the patients' head with alcohol, the stereotactic frame ring was applied with local anesthesia under di-hydroxypropylethanol sedation in the operating room. The patient was then taken to the CT room and thin slice (3-mm.) axial CT images were obtained after intravenous contrast media injection. Next, the patient was taken back to the operating room, intubated under general anesthesia and the stereotactic frame ring was fixed to the operating table with the help of a special adapter. During these preparations, the best axial CT images showing the target lesion were obtained from the radiology department and transferred to a notebook computer via a special computer program. Calculations for the target lesion and entry point were made in the operating room. Two different neurosurgeons always made the calculations separately to prevent mistakes. We used 1-gr. intravenous cephalosporin for each procedure. Only a small area of the hair was shaved and cleaned with betadine. After obtaining the coordinates from computer calculations, a specially designed arc frame was attached to the ring frame and a burr hole 1 cm in diameter was performed for the entry point. In order to prevent hemorrhage, we paid special attention to avoid sulci and the major vessels while choosing the entry point and the trajectory of the stereotactic probes. For contrast-enhancing lesions, we started to take biopsies beginning from 10-mm peripheral to the lesion and obtained 15-20 sequential specimens from the periphery of the lesion, the contrast-enhancing ring and deeper areas of the lesion at 1-mm. intervals. For non-contrast enhancing lesions, we targeted a central site of the lesion and obtained 10-15 sequential biopsies at 1-mm intervals. After completing the procedure, the patient was taken to his bed and followed-up for the next few days. No follow-up brain tomography was performed postoperatively unless a hemorrhage was suspected during the procedure and the patients were monitored using frequent neurological examinations.

RESULTS

A total of 100 stereotactic surgery procedures were performed on 94 patients. The localizations of the lesions were n=13 frontal (13.83%), n=20 temporal (21.27%), n=26 parietal (27.66%), n=4 occipital (4.25%), n=4 multiple (4.25%), n=26 deep seated (27.66%) and n=1 suprasellar (1.06%) (Table 1). The histopathological diagnoses are summarized in the (Table 2). Briefly, n=58 (61.71%) of the diagnoses were neuro-epithelial tumors, n=8 (8.51%) were metastases and n=10 (10.64%) were inflammatory pathologies. Among 94 patients, nine of the results (9.58%) were reported as ‘normal brain tissue’ and four of the results (4.26%) were reported as ‘gliosis’. Overall, a definitive histopathological diagnosis could be reached in the first CT-SBB session in 81 out of 94 (86.16%) of the patients. Five patients initially diagnosed as ‘brain tissue’ or ‘gliosis’ needed a second or third SBB session for the definitive diagnosis (Table 3). We lost contact with the remaining eight patients who had an initial biopsy result of either ‘brain tissue’ or ‘gliosis’. Ten patients underwent a craniotomy for cyto-reductive surgery after the SBB procedure (Table 3). Of these patients, the final diagnosis was changed from necrosis to glioblastoma in one patient. The rest of the diagnoses were identical to the initial diagnoses. The diagnostic accuracy was 90% (9 out of 10 cases) in our series.

We did not encounter any mortality secondary to the surgical procedure; however, one patient

Table I: Anatomical distribution of the brain lesions in 94 patients.

Location	Number of patients (%)
Lobar	
Frontal	13 (13.83)
Temporal	20 (21.27)
Parietal	26 (27.66)
Occipital	4 (4.25)
Deep-seated	
Thalamus, basal ganglia, upper brainstem	26 (27.66)
Multiple	4 (4.25)
Suprasellar	1 (1.08)
Total	94 (100)

Table II: Histopathological diagnoses of the brain lesions in 94 patients.

Diagnosis	Number of patients (%)
Neuro-epithelial tumors	
Low-grade astrocytoma	19 (20.21)
High-grade astrocytoma	15 (15.96)
Glioblastoma	18 (19.15)
Oligodendroglioma	6 (6.39)
Metastases	8 (8.51)
Inflammatory	10 (10.64)
Others	
Vasculitis	1 (1.06)
Necrosis	1 (1.06)
Lymphoma	1 (1.06)
Ischemia	1 (1.06)
Craniopharyngioma	1 (1.06)
Non-diagnostic cases	
Brain tissue	9 (9.58)
Gliosis	4 (4.26)
Total	94 (100)

diagnosed with vasculitis had a small convexity subarachnoidal hemorrhage and another procedure had to be stopped due to a non-symptomatic intraparenchymal hematoma.

DISCUSSION

Although advances in the modern imaging techniques provide early detection of brain lesions, they fail to give an accurate histopathological diagnosis which is necessary in the planning of a rational treatment strategy. Tumors suggesting a benign pathology in radiological examinations might end-up with a malignant histopathological diagnosis, or radiologically malignant tumors might turn out to be benign lesions histopathologically [25,28,29]. Since a definitive histopathological diagnosis is needed before starting an appropriate type of treatment, image-guided stereotactic techniques are widely used for intracranial lesions for their safety and accuracy.

The stereotactic brain biopsy (SBB) is indicated for the histopathological diagnosis of a deep-seated lesion or a lesion in the eloquent areas of the brain

Table III: Comparison of the histopathological diagnoses in the patients undergoing a second or third CT-SBB and/or craniotomy.

1st. Stereotactic biopsy	2nd. Stereotactic biopsy	3rd. Stereotactic biopsy	Craniotomy
Brain tissue	Gliosis	Low-grade astrocytoma	
Brain tissue	Low-grade astrocytoma		
Brain tissue	Low-grade astrocytoma		Low-grade astrocytoma
Brain tissue	Oligodendroglioma		Oligodendroglioma
Gliosis	Low-grade astrocytoma		Low-grade astrocytoma
High-grade astrocytoma			High-grade astrocytoma
High-grade astrocytoma			High-grade astrocytoma
High-grade astrocytoma			High-grade astrocytoma
High-grade astrocytoma			High-grade astrocytoma
High-grade astrocytoma			High-grade astrocytoma
High-grade astrocytoma			High-grade astrocytoma
Oligodendroglioma			Oligodendroglioma
Necrosis			Glioblastoma
Total	5	1	10

that could be approached by craniotomy with high risk to the patient, for a diagnosis of diffuse-infiltrative brain lesions, multiple lesions, cystic lesions and for the patients with poor medical conditions for a craniotomy. In these patients, stereotactic biopsy provides a small sample of a tissue from a target point predetermined by radiological methods with low morbidity and mortality rates [22]. In a review of large stereotactic brain biopsy series, the morbidity rate was reported as 3.5% (range 0% to 13%) and the mortality rate was reported as 0.7% (range 0% to 2.6%) [15]. Reported morbidity related to SBB includes hemorrhage, seizure, stroke, infection, cerebrospinal fluid leakage and tumor seeding [2,15,21,22]. Preoperative anti-platelet drug use, corticosteroid use, deep or eloquent location, high-grade glioma, multiple needle insertions and taking high numbers of specimens have been stated as the risk factors for SBB [19,20,23,32].

The most common cause of the SBB related morbidity and mortality is hemorrhage [22,23]. Kreth et al. reported a silent hemorrhage rate of 9.6% and symptomatic hemorrhage rate of 0.9% in their series of 326 patients [21]. Detailed preoperative surgical planning, using small biopsy forceps, limiting the number of specimens and performing intra-operative histopathological examination, avoiding pial/ependymal surfaces in trajectory

planning and using technologies such as multiplanar image guidance, preoperative angiography and intra-operative Doppler are recommended to decrease SBB-related morbidity and mortality [15,21,22,33]. There were no SBB-related morbidity or mortality in our series. However, we encountered two asymptomatic hemorrhages (2.12%), the first one was a superficial convexity subarachnoid hemorrhage in a patient diagnosed as vasculitis eventually and the other was an intra-parenchymal hemorrhage in a patient with glioblastoma. In the latter patient, the biopsy procedure had to be stopped due to observation of hemorrhage from the biopsy cannula but the histopathological examination of the specimens was able to reveal the diagnosis. These two patients were taken to the CT room immediately after the procedure and the diagnosis of hemorrhage was confirmed. On the other hand, we did not perform postoperative CT examination routinely and the actual rate of hemorrhage in our series could be higher.

Regarding the histopathological results, CT-guided stereotactic brain biopsy provided a diagnostic yield of 86,16% in our series. This result is in accordance with other studies reported in the literature (range 80% to 99%) [10-13,15,16,29,32,34]. We utilized a flexible cup forceps type probe (opening mouth of 1 mm) in an arc-based system for biopsy. The arc-based CT-SBB system allowed us

select a convenient and safe probe trajectory, and the type of biopsy forceps we used provided adequate tissue sampling for a variety of lesion types and texture. Although this type of probe can cause complications due to traction of the neighboring vessels, this can be avoided by careful selection of the biopsy probe trajectory or using another type of biopsy probe as needed. For homogenous lesions, we obtained 10-15 sequential biopsies in 1 mm increments from the target point. For heterogeneous lesions, we obtained 15-20 sequential specimens from periphery of the lesion, from the contrast-enhancing ring and from deeper areas of the lesion. Several authors underlined the significance of the number of biopsy specimens in order to achieve a high rate of diagnostic yield [1,4,30]. Complying with this implication, the number of specimens in our series provided enough tissue for histopathological examination. However, we did not perform intra-operative frozen section or cytological examination techniques during the procedure. In 13 of our patients (13.84%), we were not able to achieve a definitive histopathological diagnosis from the paraffin-embedded sections and we believe one of the reasons for this failure could be the lack of utilization of these methods at the time of biopsy. In the literature, a great number of authors stressed the value of using either of these techniques [4,9,31]. In the series of Kim et al. a statistically significant difference was reported between the CT-SBB with and without frozen section examination [19]. Another reason for the non-diagnostic results in our series could be the technical errors during the procedure. SBB is a very sensitive procedure and the neurosurgeon relies entirely on adjunctive technologies for guidance. A small error at any stage of the procedure leads to inaccurate lesion targeting. This possibility can be minimized by meticulous attention to detail and by providing an experienced team of neurosurgeon, neuroradiologist and neuropathologist.

Another limitation of SBB is the diagnostic accuracy of the procedure. The diagnostic accuracy is defined as determining the correct pathology and, in the case of a tumor, correct tumor type and grade. The size and the number of biopsies are limited in the SBB procedure and may not be representative of the whole lesion. The diagnostic accuracy of SBB ranges from 80% to 96.7% in the literature

[5,8,14,18,19,22,33]. SBB has a higher diagnostic accuracy rate in homogenous lesions, but the accuracy is poorer in heterogeneously enhanced lesions. Avoiding the central hypo-dense areas and taking biopsies only from well-enhanced regions during sampling results in under-grading [6,30]. In their series, Jackson et al. reported that 60% of their cases initially diagnosed as anaplastic astrocytoma were upgraded to glioblastoma in the end [18]. Furthermore, tumors of mixed nature (e.g. oligo-astrocytoma, germ-cell tumors) could be diagnosed incorrectly because of sampling limitations. In our series, 10 patients underwent a craniotomy after the SBB procedure. Of these patients, the final diagnosis was changed from necrosis to glioblastoma in one patient and the rest of the diagnoses were identical to the initial diagnoses. The diagnostic accuracy was 90% (9 out of 10 cases) in our series; however, the small number of patients undergoing craniotomy limited the value of this conclusion. A number of methods have been advocated to increase the accuracy of the SBB such as targeting multiple regions of the lesion, delaying the localization scan after the administration of contrast medium to improve resolution and target selection, using intraoperative frozen section or cytological examinations, utilizing modern histopathological techniques (e.g. immunohistochemistry and MIB-index) and using PET or MR-spectroscopy techniques for stereotactic biopsy [3,7,19,22,24,27,28].

CONCLUSION

CT-guided SBB is a reliable and safe procedure in the diagnosis of intracranial lesions. The main diagnostic problems in SBB are tissue heterogeneity of the target lesion, insufficient material and sampling error. These problems can be minimized by careful correlation of clinical, radiological and histopathological findings by an experienced team and by using modern technologies.

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