A comparison of computerized tomography-guided stereotactic and ultrasound-guided techniques for brain biopsy

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Forty-one patients with brain lesions underwent brain biopsy using either a computerized tomography (CT)-guided stereotactic approach or an ultrasound-guided technique. The cases were selected according to location and size of the mass lesion. Lesions 15 mm or less in diameter and those in the posterior fossa were biopsied by a CT-guided stereotactic technique (18 patients). Supratentorial lesions with a diameter larger than 15 mm were approached using ultrasound guidance (23 patients). These criteria for procedure selection provided a diagnostic yield of 94% for the CT-guided procedures and 91% for those guided by ultrasound. Safety for the two procedures was similar. The ultrasound procedure was more rapid, simpler, and less costly to perform. It is concluded that, with the protocol described, CT-guided stereotactic procedures could be reserved for cases in which absolute accuracy is mandatory.

KEY WORDS • stereotaxis • biopsy • computerized tomography • ultrasound

Dramatic progress in brain imaging during the last decade has renewed interest in stereotactic brain biopsy. Computerized tomography (CT), which allows early recognition and accurate definition of cerebral lesions, is widely used to guide calculation of stereotactic coordinates with nearly all stereotactic devices presently available.2,4,10,13,15 Stereotactic biopsy now ranks as a low-risk procedure with high diagnostic reliability. In many neurosurgical centers, this is a routine procedure to achieve a histological diagnosis when formal surgery is not indicated or will be dictated by the pathology of the lesion. However, CT-guided stereotactic biopsy is time-consuming and costly.9,18,20 As the procedure takes place partly in the CT suite, the scanner is temporarily unavailable for other studies. In addition, any changes in localization that might arise during the procedure, such as after aspiration of a cyst, may require a repeat CT scan to recalculate the stereotactic coordinates. To overcome these disadvantages, the search for an alternative technique has recently focused on ultrasound-guided brain biopsy.3,5,7,8,14,16-20 Current technical improvements, including high-resolution and smaller ultrasound probes, permit good-quality brain imaging through a burr hole that is only slightly larger than usual.3,8,14,16,20 Despite the undoubtedly superior accuracy of CT-stereotactic biopsy, experience demonstrates not only that ultrasound guidance is feasible1 but also that it has certain advantages. The ultrasound procedure is quicker to perform, requires less CT scanning, and reduces overall costs. Changes in target volume and position as well as accidental postbiopsy hemorrhage can also be visualized promptly and repeatedly in the operating theater.

Before this pilot study, biopsies were routinely performed by CT-guided stereotactic technique in our center. Here we evaluate criteria designed to indicate the most suitable operating technique, CT-guided stereotactic biopsy, or ultrasound-guided biopsy, according to the localization and size of the brain lesion to be biopsied. With the proper protocol, the CT-guided procedure could be reserved for cases in which absolute accuracy is mandatory.

Clinical Material and Methods

Patient Population

Our study group consisted of 41 patients undergoing biopsy for CT-demonstrated intracranial lesions between January, 1989, and September, 1990. Eighteen biopsies were obtained under CT-guided stereotactic procedures and 23 under ultrasound guidance. The age and sex distribution of the patients were similar in both
groups. Six of the lesions biopsied by the CT-guided stereotactic technique were located in the basal ganglia, three in the suprasellar region, three in the cerebellum, two in the brain stem, two in the subcortical hemisphere, one in the intraventricular region, and one in the pineal region. Sixteen of the lesions biopsied under ultrasound guidance were located in the subcortical hemisphere, six in the basal ganglia, and one in the corpus callosum. All patients underwent a preoperative high-resolution contrast-enhanced CT scan; selected patients underwent cerebral angiography. All patients had antibiotic prophylaxis and steroid therapy; patients with supratentorial lesions also received anticonvulsant drugs. Biopsy procedures were usually performed with the patient under local anesthesia; some patients were mildly sedated. Only two uncooperative patients (a child and a mentally retarded adult) needed general anesthesia and endotracheal intubation.

Operative Guidelines

Needle biopsy of small lesions, 15 mm or less in diameter, and lesions in the posterior cranial fossa was performed by the CT-guided stereotactic technique. Biopsy of supratentorial lesions over 15 mm in diameter was guided by ultrasound.

CT-Guided Stereotactic Biopsy

The CT-guided stereotactic biopsies were performed with the CT-compatible headframe of the Leksell stereotactic system in conjunction with a CT scanner.* Available computer software for this scanner was used to calculate the stereotactic coordinates of the biopsy targets. A standard burr hole was drilled, in most cases just behind the coronal suture, 2.5 cm lateral to the midline. After the dura mater was opened, multiple biopsy specimens were taken along one or more previously chosen trajectories. A CT scan was obtained immediately after biopsy to check for possible complications.

Ultrasound-Guided Procedure

For ultrasound-guided biopsies, preoperative CT-guided placement of a burr hole, 22 mm in diameter, was performed through a small linear scalp incision. Biopsy was guided by a portable real-time ultrasound sector scanner with a small scan head containing a 5.0-MHz transducer.† The scan head was fitted into a small sterile rubber glove partly filled with an acoustic coupling gel. The connecting cable was covered with a sterile sheath. The stereotactic ultrasound apparatus was then mounted and the biopsy procedure performed as described by Berger.‡ Multiple biopsies were taken in all cases. An ultrasound scan was performed 15 minutes after the biopsy to image the needle tracks and check for hemorrhage. Only the patients treated early in this series had a postoperative CT control scan.

Results

The mean operative time from headframe mounting to discharge in the recovery room was 236 minutes (3.9 hours) in the 18 patients undergoing CT-guided stereotactic biopsy (including an average of 63 minutes spent in the CT suite) compared with 56 minutes for the 23 patients with ultrasound-guided biopsy. An average of 5.8 biopsy samples was obtained during the CT procedure and 5.5 during the ultrasound procedure.

Tissue samples were obtained in all cases. In 17 (94.4%) of the 18 patients in the CT group and 21 (91.3%) of the 23 patients in the ultrasound group, the first biopsy procedure established a histological diagnosis. One patient in the CT group and two in the ultrasound group needed a repeat procedure, which was performed with a CT-guided stereotactic technique (Table 1).

Complications were encountered in five patients: two patients whose neurological deficits transiently worsened because of postbiopsy edema, two cases of subcortical hemorrhage not requiring surgical evacuation, and one case of intraoperative seizures (Table 1). Postoperative mortality was nil; no wound infections occurred.

Lesions biopsied by the CT-guided stereotactic technique were histologically diagnosed as metastases in six cases, astrocytomas in four, craniopharyngiomas in two, and as glioblastoma, pineoblastoma, non-Hodgkin's lymphoma, radionecrosis, encephalitis, and infarction in one case each. Lesions biopsied under ultrasound guidance were diagnosed as glioblastomas in 10

<p>| TABLE 1 |
| Operative results and complications associated with two biopsy methods |</p>
<table>
<thead>
<tr>
<th>Characteristic</th>
<th>CT-Guided Biopsy</th>
<th>Ultrasound-Guided Biopsy</th>
</tr>
</thead>
<tbody>
<tr>
<td>no. of cases</td>
<td>18</td>
<td>23</td>
</tr>
<tr>
<td>positive histological diagnosis at 1st attempt</td>
<td>17 (94.4%)</td>
<td>21 (91.3%)</td>
</tr>
<tr>
<td>further procedure necessary</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>effect on neurological deficits</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>improved</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>worsened</td>
<td>14</td>
<td>20</td>
</tr>
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<td>1</td>
</tr>
<tr>
<td>morbidity</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>subcortical hemorrhage</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>intraoperative seizures</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>wound infection</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* CT = computerized tomography.
‡ All neurological improvements were obtained as a consequence of concomitant cyst aspiration.
Stereotactic vs. ultrasound-guided biopsy

cases, astrocytomas in eight, metastases in four, and non-Hodgkin’s lymphoma in one. Eight patients, five in the CT-guided stereotactic group and three in the ultrasound group, later underwent a formal craniotomy; histological study of the surgical specimen invariably confirmed the biopsy diagnosis. The duration of hospitalization, similar in the two groups, averaged 3.5 days for the patients needing only a biopsy.

Discussion

Experience acquired over recent years demonstrates that CT-guided stereotactic biopsy is a low-risk procedure that allows the probe to be placed with extreme accuracy, reportedly within 1 mm of the target. However, the procedure calls for costly equipment and necessary staff training. After headframe mounting, the patient has to be moved to the CT suite for stereotactic determination of the coordinates of the targets, then returned to the operating theater for the biopsy procedure. As a control CT scan is usually performed, the entire process is time-consuming and requires strictly coordinating the facilities (operating theater and CT suite) and close cooperation between dedicated staff (neurosurgeons, neuroradiologists, CT technicians, and auxiliary personnel). Costs are therefore high. In contrast, the ultrasound procedure takes place entirely in the operating theater.

In our experience, the mean operative time for an ultrasound-guided biopsy is significantly shorter than that for a CT-guided stereotactic biopsy (56 vs. 236 minutes, p < 0.001 by Student’s t-test); for the ultrasound procedure, no time is spent in the CT room. Although we initially performed a postbiopsy CT control scan after the ultrasound procedures, this step was subsequently omitted because ultrasound scanning is capable of detecting hemorrhagic complications.

Although ultrasound-guided biopsy has been reported to be suitable for lesions larger than 5 mm, nonetheless, we have preferred to use it only for lesions over 15 mm in diameter. We biopsied all posterior cranial fossa lesions with the CT-guided stereotactic technique. These guidelines ensure acceptably safe procedures with a comparable diagnostic yield for the two methods. The undoubted advantage of the CT technique is its high accuracy; nevertheless, the ultrasound-guided procedure is simpler, quicker, and more economical to perform. These two procedures are complementary: both have their place in neurosurgical practice.

References


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