Identification of residual glioma using ultrasound miniprobes

TO THE EDITOR: We read with great interest the paper written by Prada et al. (Prada F, Del Bene M, Fornaro R, et al: Identification of residual tumor with intraoperative contrast-enhanced ultrasound during glioblastoma resection. Neurosurg Focus 40(3):E7, March 2016) describing the benefits of contrast-enhanced ultrasound (CEUS) use during glioblastoma surgery. The authors should be commended for popularizing this technology among neurosurgeons. In fact, our interest in CEUS was triggered after reading the important study by Prof. DiMeco’s group, and we started to perform this technique at our department this year. CEUS appears to be undoubtably very promising in oncological as well as in vascular neurosurgery.

Nevertheless, we would like to comment on the authors’ discussion concerning identification of residual glioma tissue using CEUS versus identification using a miniature US probe inserted into the resection cavity—a technique we presented in 2012. Prada et al. correctly pointed out the fact that small probes have a limited field of view. However, we cannot agree with the statement that it is not possible to obtain an overview of the anatomy and residual mass entity by using miniprobes. Indeed, the limited field of view of miniprobes is a significant limiting factor predominantly when these probes are used with a 2DUS system; in that case the anatomical orientation certainly may be difficult. In contrast, when minature probes are used with navigated 3DUS systems, which allow rendering of the US image in orthogonal planes (axial, coronal, and sagittal) and automatic fusion with preoperative MRI sequences, the anatomical orientation and residual tumor identification is usually not a major challenge. These systems use US probes equipped with reflective marker reference frames; the 3DUS data are acquired by freehand probe movement, tracking the position and orientation of the probe by means of a navigation camera system. After scanning (i.e., 3DUS data acquisition), 3DUS systems enable surgeons to visualize and navigate the whole volume of normal and pathological tissue that was scanned; thus the narrow field of view of miniprobes is not a significant limiting factor, because the volume of tissue scanned and subsequently visualized can be relatively large. In addition, the 3DUS data acquired during several scanning sessions can be fused into a single image. This might be helpful in situations in which a superficial vessel crosses the resection cavity and hinders sufficient movement of an inserted miniprobe, and thus precludes scanning of the whole bottom of the resection cavity during a single scanning session. Of note, the whole process of rendering the US image in 3 dimensions and the automatic fusion with preoperative MRI sequences (or other US data) takes only few seconds.

A significant benefit of the use of miniprobes is the fact that their insertion into the resection cavity enables distinct visualization of both normal and pathological structures at the resection cavity bottom (Fig. 1). When the resection cavity is scanned using a US probe placed on the brain surface, its bottom is often depicted indistinctly due to the acoustic enhancement artifacts (AEAs); these are the most common and dominant image artifacts in intraoperative US imaging of brain tumors. The AEAs appear when US penetrates a higher column of water (saline) as a result of the large difference between a very low attenuation of acoustic waves in water (saline) and high attenuation in brain tissue. By inserting the miniprobe into the resection cavity, the column of saline between the tip of the probe and scanned tissue at the bottom of the resection cavity gets smaller (or is even absent if the tip of the miniprobe touches the bottom); shortening the column of saline reduces the AEAs and enables better visualization of the structures at the resection cavity bottom (Fig. 1). Additional use of the 3DUS power-Doppler mode (Fig. 2) further facilitates the surgeon’s anatomical orientation and contributes to the safety of the procedure. Moreover, integration of all updated data into a single comprehensible image is possible by performing a fusion of the US image obtained with a probe placed on the brain surface (showing the whole resection cavity and adjacent tissue) and the image data obtained with a miniprobe distinctly visualizing the medial part of the resection cavity (Fig. 3).

Importantly, considering the specificities of both methods, identification of residual lesion by using miniprobes might be superior in some glioma types to use of CEUS. Besides imaging of various lesions, small US probes inserted into the resection cavity generally enable direct visualization of residual mass also in Grade II astrocytomas; these tumors are most often hyperechoic. The role of CEUS in visualization of residual Grade II astrocytomas needs to be determined, considering the facts that these tumors often have limited vascularity and that...
FIG. 1. Visualization of a right-sided insulo-opercular Grade II astrocytoma before and during resection. The yellow lines and the center of their intersection are placed on all images at an identical point of the cranial cavity. A: Preoperative 3D FLAIR MRI axial and coronal sequences. B: Preresectional intraoperative 3DUS image performed with large version of a flat linear array (FLA-L) probe, frequency range 6–12 MHz (SONOWAND AS) fused with navigation MRI sequence. Red arrows designate the medial tumor border, and black arrows the superior perinsular sulcus. C: A 3DUS scan performed from the brain surface during the resection using an FLA-L probe. White line designates the virtual position of the probe during the scanning. Note that due to AEAs (white arrows) the hyperechoic area extends far more medially than was the position of the medial tumor border, which cannot be reliably recognized because it is overlapped by AEAs; blue arrowhead points to the superficial vein crossing the resection cavity. D: A 3DUS image acquired via scanning with a minicraniotomy (MC) probe, frequency range 5–10 MHz (SONOWAND AS), inserted within the resection cavity; the AEAs are minimized. Note distinct visualization of the medial tumor border (red arrows). Two scanning sessions were performed and fused; black and white lines depict the virtual position of the miniprobe during the scanning. Note that a large area of brain could be visualized using the miniprobe.

FIG. 2. Use of 3DUS power-Doppler mode. A: Preresectional 3DUS image performed with a 12-FLA-L probe fused with navigation MRI FLAIR sequence and 3DUS power-Doppler data; 3DUS angiography was performed using a flat phased array (8-FPA) probe, frequency range 3–8 MHz (SONOWAND AS). Note that one of the lenticulostriate arteries (arrow) is just medial to the medial tumor border. B: A 3DUS scan performed from the brain surface during the resection using a 12-FLA-L probe fused with 3DUS power-Doppler data; note that the lenticulostriate artery (arrow) is now within the hyperechoic area of the AEAs, and the medial margin of tumor is not identifiable. C: A 3DUS image acquired via scanning with an MC probe inserted within the resection cavity fused with 3DUS power-Doppler data. Note that the medial tumor margin and its anatomical relationship with the lenticulostriate artery (arrow) is distinctly depicted, and the AEAs are minimized.