

INTRAOPERATIVE ULTRASOUND IN LOW GRADE GLIOMAS

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RÉSUMÉ : Vingt patients qui présentent des gliomes de bas grade ont été évalués avec une résonance magnétique préopératoire (IRM) et une échographie peropératoire (IOUS). Les frontières des tumeurs en peropératoire, ont été marquées avec des lettres posés sur le cortex et la profondeur correspondante a été calculée. La résection de la tumeur correspondait à ces dimensions échographiques. Les tumeurs ont toutes été observées lors d'études IRM préopératoires et ont montré le plus souvent une diminution de l'augmentation du signal T2. Sept tumeurs ont montré une augmentation variable avec le gadolinium. Toutes les tumeurs étaient hyper-échogènes à l'échographie. 90% des tumeurs étaient bien définies avec des marges distinctes par rapport au cerveau adjacent. Deux tumeurs avaient des frontières mal définies à l'échographie. Huit tumeurs ont envahi le cerveau fonctionnel identifié par des techniques de cartographie de stimulation (par exemple, cortex vocal), limitant ainsi la résection. Les gliomes de bas grade sont facilement identifiés et leurs marges bien définies par les ultrasons peropératoires, quels que soient les profils d'imagerie préopératoire. Les résultats suggèrent que IOUS peut améliorer la délimitation peropératoire et l'étendue de la résection pour les gliomes de bas grade.

Mots clés : Cerveau, Tumeur, Gliome, MRI, Echographie.

ABSTRACT : Twenty patients with low grade gliomas were evaluated with preoperative magnetic resonance (MR) and intraoperative ultrasound (IOUS). Tumor borders were marked with cortical letters and corresponding depths calculated. Resection of tumor corresponded to these ultrasound dimensions. Tumors were all seen on preoperative MR studies and most commonly showed a decreased T1 and increased T2 signal. Seven tumors showed variable enhancement with gadolinium. All tumors were hyperechoic on ultrasound. 90% tumors were well defined with distinct margins compared to adjacent brain. Two tumors had poorly defined borders on ultrasound. Eight tumors invaded functional brain identified by stimulation mapping techniques (e.g., speech cortex), thus limiting the resection. Low grade gliomas are readily identified and their margins well defined by intraoperative ultrasound regardless of preoperative imaging patterns. The results suggest that IOUS may enhance intraoperative delineation and extent of resection for low grade gliomas.

Key words : Brain neoplasm, Glioma, Magnetic resonance image, Ultrasonography.

INTRODUCTION

The management of supratentorial neoplasms suggests that outcome may be enhanced when maximal surgical resection is achieved prior to adjuvant therapies.

Precise localization of histologic margins of the tumor is crucial for surgical planning.

However, tumor boundaries may often be difficult to define intraoperatively, particularly in low grade gliomas, and despite the advances made in neuroimaging neither magnetic resonance (MR) imaging provides precise determination of intraxial tumor margins.

In view of this we elected to compare preoperative imaging studies including IRM and intraoperative ultrasound of low grade gliomas, and assess the efficacy of the ultrasound studies in localizing these lesions and their solid borders to enhance tumoral removal.

CLINICAL MATERIAL AND METHODS

Twenty patients with low grade gliomas were evaluated with an age range of fifteen to sixty year (median 35 years). Local tumor relapse was diagnosed using MRI.

The operations were performed using awake technique with the goal of gross tumor resection. IOUS was used after craniotomy throughout the entire operation until the dura mater was closed.

All tumors were evaluated with portable real-time sector scanner.

The transducer frequencies included 3.5, 5.0 and 7.5 MHZ to maximize tumor resolution and margin identification.

The probe was moved across the operative field providing a real-time image of the lesion and surrounding anatomy.

Tumors were hyperechoic in comparison to surrounding brain.

Under ultrasound guidance, tumor margins were marked by placement of letters (A,B,C...) on the cortical surface and determination of the corresponding depth. The extent of tumor resection was guided by the intraoperative ultrasound findings.

Resection was not done in areas where tumor invaded functionally eloquent regions, such as speech cortex, or internal capsule identified by stimulation mapping techniques.

Positive correlation existed between both IOUS and T1 ($p < 0.001$) and IOUS and T2 ($p < 0.001$) volume estimates.

There was a tendency for IOUS volumes to be larger than T1 volumes ($p = 0.07$).

Although not statistically significant, IOUS and T2 estimates appeared similar ($p = 0.8$).

RESULTS

All 25 of the samples obtained from unequivocal tumor tissue were indeed classified as malignant glioma in the histopathological examination. All samples were resected from tissue that was hyperechoic on IOUS.

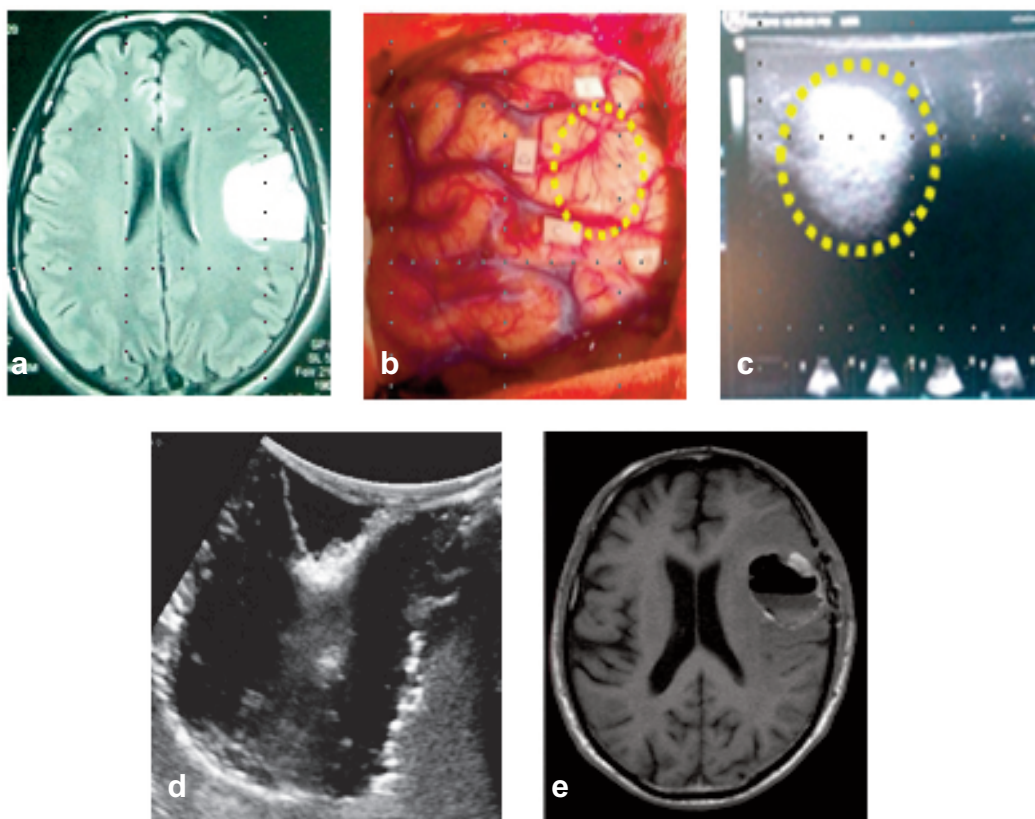


Fig. 1. A 40-year-old man with a left Frontoparietal glioma,
A. Coronal magnetic resonance imaging (MRI) (T1, FLAIR) defines the extent of tumor. **B.** Intraoperative view the letters corresponding to tumor margins **C** ultrasonography (IOUS) before tumor resection (coronal image) reveals hyperechoic tissue. **D.** Coronal IOUS shows the extent of resection; at the border, **E.** The postoperative coronal MRI (T1, contrast-enhanced) after resection shows only linear contrast media enhancement

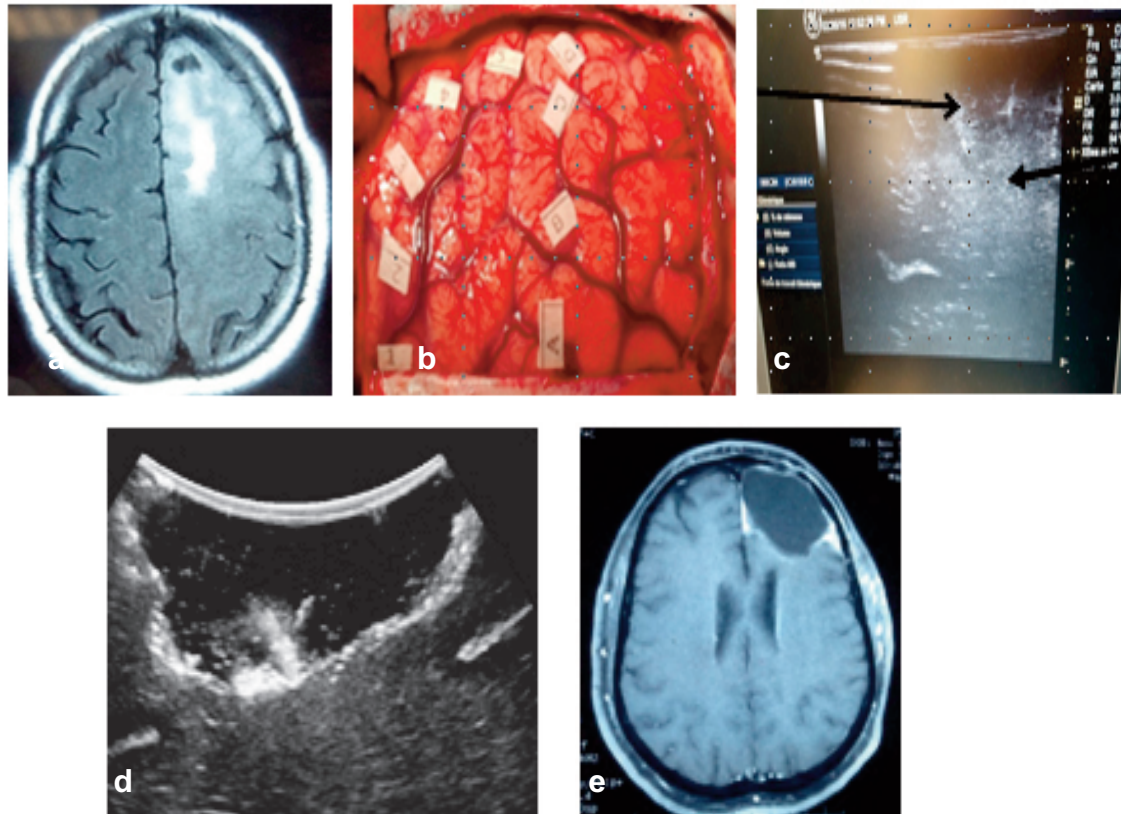


Fig. 2. A 42 -year-old man with a left frontal glioma,
A. Coronal magnetic resonance imaging (MRI) (T1, FLAIR) defines the extent of tumor.
B. Intraoperative view the letters corresponding to tumor margins **C** ultrasonography (IOUS) before tumor resection (coronal image) reveals hyperechoic tissue. **D.** Coronal IOUS shows the extent of resection; at the border, **E.** The postoperative coronal MRI after resection shows only linear contrast media enhancement.

Patients	Age	Sex	Previous surgery	RM	IOUS	Pathology
1	18	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins Homogenous Hyperechoic Defined margins	Grade II astrocytoma Grade II astrocytoma
2	35	M		Decreased T1 Increased T2		
3	60	M		Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	
4	36	M		Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	
5	44	F	N	No change T1 increased T2	Homogenous Hyperechoic III defined margins	Grade II astrocytoma
6	39	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic ystic changes	Mixeg glioma
7	37	M	W	Decreased T1 TM Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
8	59	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	
9	33	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Oligodendroglioma mixed glioma
10	19	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
11	45	M		Decreased T1 N Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
12	41	F		Decreased T1 N Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
13	22	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
14	18	M	Y	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Oligodendroglioma
15	39	F	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Mixed glioma
16	45	M		Decreased T1 N Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
17	44	F	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Mixed glioma
18	23	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
19	29	M	N	Decreased T1 Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma
20	40	M		Decreased T1 TM Increased T2	Homogenous Hyperechoic Defined margins	Grade II astrocytoma

Table 1 : magnetic resonance, intraoperative ultrasound, pathology and margin histology in patients with low grade glioma.

DISCUSSION

The delineation of tumor margins at the time of surgery is crucial to achieve a maximal surgical resection of supratentorial gliomas which, subsequently may enhance survival.

Ideal methods to differentiate gliomas from normal brain include [3] easy to perform and accurate [5] real-time that is concordant with a surgeon's view and may be monitored continuously, [14] maximal functional protection [4] minimal technical challenges, and [12] cost-effective such IOUS.

IOUS has been used for navigation and resection control in intracranial surgery for decades [6]. Previously, doubts have been raised that this method can quantify the extent of residual tumor, especially during glioma resection, but it nonetheless has become accepted as a valuable tool contributing to control of the resection.

Innovative techniques, such as three-dimensional imaging and high-frequency ultrasonography, have reportedly improved operative results. This study was designed to assess the efficacy of intraoperative ultrasound in defining the margins of low grade gliomas [16].

Intraoperative cerebral ultrasonography uses ultrasonic waves to highlight the injury. Images are formed by analyzing the reflected waves from interfaces situated at different distances from the transducer [18].

As Keles et al. stated the main advantage is that the intraoperative ultrasound is a real time examination performed on certain anatomical features of each operative field. As it requires a certain pressure on the cortex during ultrasound examination [10], the brain structures and the image of the lesion are slightly modified from that of CT or MRI investigations but, with all those the relationship between them remains the same. All tumors were hyperechoic relative to adjacent brain irrespective of their preoperative imaging pattern.

The majority of these lesions were well defined with distinct borders on ultrasound.

Thus, we elected to combine intraoperative ultrasound studies with information obtained from preoperative images to enhance surgical resection. When compared to CT, tumor size often

appears larger and of a different configuration on MR studies, particularly T2 weighted images.

Mc Gahan, et al. have correlated autopsy specimens of gliomas with ultrasound and demonstrated a close histologic relationship between neoplastic tissue and echogenic

region [11].

Acoustic shadowing occurred when calcification was present and cystic changes were readily identifiable.

In reoperated tumors, ultrasound may overestimate tumor size and the presence of gliosis may contribute to the irregular tumor outline. Most authors report edema as hypoechoic or isoechoic on ultrasound studies [8, 13].

Quencer and Montlavo and Smith have reported increased echogenicity corresponding to areas of edema on imaging.

However, this echogenic pattern was different from that of tumor tissue and did not interfere with the definition of tumor margins.

A positive correlation existed between both ultrasound and T1 and T2 weighted volumes of low grade gliomas. There was a tendency for ultrasound to be larger than T1 but similar to T2 tumor volumes.

Both Enzmann and Knake found that tumor size on ultrasound was never smaller than that on T2 weighted MR volumes are usually larger than corresponding CT or T1 MR weighted images and scattered tumor cells are often found in these regions [7].

There are some rare cases where the tumor is not so well defined in MR flair. In these cases it can be hard to see the tumor also in ultrasound image.

The special value of IOUS, its real-time character, cannot be overemphasized. The intraoperative situation may change rapidly due to the collapse of cysts or the occurrence of hemorrhages [1, 2], and every possible tool for visualizing such changes should be utilized.

A neurosurgeon who is facing the special situation of relapsed glioma may appreciate this option for navigating towards the bulk of the tumor. This may indeed be helpful when three-dimensional IOUS, navigated IOUS, or intraoperative MRI (which, according to some investigators [17], may be superior to IOUS) are not available.

In the end of operation we can have ultrasound image artefacts, the cause is attenuation in sound waves in the brain tissue and the saline used to fill the operation cavity [9, 15].

CONCLUSION

Low grade glioma represent a special challenge in glioma surgery.

It is often difficult to differentiate tumor tissue from normal tissue visually.

Therefore, Real-time B-mode intraoperative ultrasound is a complementary, convenient and user-friendly method for identifying, localizing, characterizing the pathological aspects, assessing the extent of tumor resection, pointing the relationships with surface and deep cerebral structures. The intraoperative ultrasound scanning is a useful medical tool, which doesn't exclude the CT and MRI examinations, and needs a good understanding of ultra sonography and anatomy. It is considered as the neuro surgeon's "deep-seated" eye.

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